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1990 NASA AUTHORIZATION

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
SPACE SCIENCE AND APPLICATIONS

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

FEBRUARY 2, 28; MARCH 1, 7, 9, 21, 23; APRIL 4, 5, 6, 11, 18, 1989

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1990 NASA AUTHORIZATION

THURSDAY, FEBRUARY 2, 1989

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met, pursuant to call, at 1:30 p.m., in room 2325, Rayburn House Office Building, Hon. Bill Nelson (Chairman of the subcommittee), presiding.

Mr. **Nelson.** If anyone has an empty chair beside you, would you raise your hand? No.

Then may I invite all of you who are standing to please come up here. Likewise, you all that are standing, please come around here. In other words, I don't want you standing.

I also want to take this opportunity to introduce to everyone a Member of Parliament of the New South Wales Legislative Assembly in Australia, Parliamentarian Jim Longley, who is with us, and we are delighted.

And I would like to also recognize my father-in-law, Tilmon Cavert, of Jacksonville, Florida, who is with us. He is going to see if his son's—if his son-in-law has got the stuffing in him today.

And we are delighted to have you today. We are really looking forward to a major year for space, and before I make my comments I would like to turn to my colleague, Mr. Sensenbrenner, for comments from him.

Mr. **Sensenbrenner.** Thank you very much, Mr. Chairman. It certainly is a pleasure being here today at my first public hearing as the new ranking Republican member of this subcommittee.

As I have said to many of you in the audience, the way we used to pick subcommittee slots on the Republican side kind of precluded senior Members from serving on the Space Subcommittee if they had a ranking position on another subcommittee. So, in my 10 years of service on this full committee this is the first time I've ever been on the Space Subcommittee and, consequently, I have a lot to learn, and starting with Dr. Fletcher and his overview of the NASA budget is a good place to start.

I'm looking forward to working with the gentleman from Florida during the next 2 years to keep our space program on track and to continue rebuilding from the Challenger disaster that put us out of the space business for far too long. There are challenges, and my feeling is that we have to work hard in prioritizing what we're going to do in space so that we can do a good job within the resources that our available to us.

I don't have anybody to introduce today, but I do want to have one aside. My father-in-law is the Chief Federal District Judge for the Eastern District of Wisconsin. He is not interested in whether I have the stuffings in me today, but he is waiting until next Tuesday to find that out. [Laughter.]

He's looking from afar. So, it is all yours today, Bill, to see if you have the stuffings in you. Thank you very much.

Mr. NELSON. Thanks, Jim.

Mrs. Morella, would you like to greet us?

Mrs. MORELLA. I would like to greet you all. I just want you to know that I did ask to be on this subcommittee again because I believe that the work that go into an authorization for our space program and for the commercialization of space is critically important. So I'm delighted to be back here for the 101st Congress, and I'm delighted with our chairman and our new vice chairman—may I call you that, sir? I am certainly looking forward to hearing Dr. Fletcher and the other representatives of NASA, so that we can move forward with a successful space program.

Thank you.

Mr. NELSON. Thank you.

And, as I said in an organization of the committee yesterday, that I'm pleased I am here again. This sort of became a very sought after subcommittee, and I'm glad that we have the hard-charging members that we do. And we're looking forward to a very vigorous year.

May I invite, again, those who are standing, there are some remaining seats right here—three—so you are welcome.

It's appropriate for us to start in the light, Dr. Fletcher, that the Challenger accident is behind us. We've got a lot of challenging tasks ahead of us and we're ready to tackle those and to continue to offer to you the cooperation and the support as you continue this task of rebuilding, as you continue to have us where America rightly belongs, and that is, that our Space Program is back on track and that we have reclaimed the high ground.

It's been a tough 3 years. The continuation of the investments in this program are just simply not going to happen by themselves. It's going to require your leadership and it's going to require our guidance and support. This is a constitutional democracy and the branches must work together, and a lot of the policy will be established by those who hold the purse strings with the consultation of you and looking to you and your agency's leadership, and particularly looking to the one person that can lead the Space Program, and that is the President, the elected leader of this country.

From time to time, we would certainly like to lead the Space Program on this committee, but we simply do not have that constituency to do so. There are a lot of good signs that are coming out of this Administration. One of the great signs is the vigor that seems to be approached with regard to the new National Space Policy Council. Now, when Jim Fletcher came to this job of Administrator his hair was already white, but it has gotten whiter as he has observed the process of space policy decision-making in these last few years, for we did not have a place where with a high level of visibility that there could be some coherence and cohesiveness and we saw sometimes space policy be made by decisions being made by indecision, and other times we saw it all over the lot in Washington.

It's interesting that we put the National Space Policy Council in the NASA authorization bill 2 years ago and it was vetoed specifically for that reason. But, alas, the 2 candidates for President—there was a method to our madness, by the way, of taking this committee to New Hampshire to Bob Smith's district and to Iowa to Dave Nagle's congressional district, 2 of the members of this committee, in the last week of January and the first week of February, when people said we were nuts, because of the weather. But we wanted to get across in what little way that we could, in addition to having 2 very fine hearings at the University of New Hampshire and the University of Iowa—2 universities that do, in fact, have very good space programs—to let the word go out about the support for the Nation's Space Program. And, lo and behold, those 2 candidates owned up to the National Space Policy Council, so that then when we added it to the NASA authorization bill and it went to the President for his signature--and it was actually signed, wasn't it, after the election, Dr. Smith? It was signed November the 15th.

Dr. WILLIAM S. SMITH, Jr. It was signed——

Mr. NELSON. October the 15th?

Dr. WILLIAM S. SMITH, Jr. October the 15th.

Mr. NELSON. Okay. It was signed just before the election. But, in that case, both candidates had signed onto it, so we didn't get a veto this time. And so we look forward to that.

We look forward to the gusto with which this Administration has approached the Space Program and the commitments that were made by Candidate Bush with regard to the Space Station and the vigor within which we're going to approach this program.

Now let me offer a caveat. I would hope that future administrations, that when they select their Council of Economic Advisers and when they select their members of their Cabinet that at the same time giving the same emphasis that they would select their Science Adviser and select their NASA Administrator, instead of letting those appointments come much later, for science and technology research and development is the future of this Nation and should be appropriately given that place in the formation of a new government.

But we've got a lot to look forward to and a lot of excitement.

Dr. Fletcher, you've heard me talk about seed corn. We talked about that when we were going through all the wrangling that we had to when we were trying to scrape up the money to keep the Space Station alive. That we didn't want to—we didn't want to start eating our seed corn, because if we did, then we're killing ourselves for the future. And so I was, I was disheartened that we didn't get all the money that we needed to get into Pathfinder and a lot of the R&D projects.

You're going to see this committee coming down hard on the question of R&D within our jurisdiction across the board, especially in science, especially in the new technologies that we've got to develop for the programs that are going to occur over the next several decades that we must start right now.

Now you've heard the phrase "space is a place." It's a place for new opportunities, it's a place for scientific and technological progress, and it's a place for achieving the American dream. But space is not a place for petty bureaucratic turf battles, and we've seen enough of those in the past. And it is my hope that in this new Administration and under your leadership, Dr. Fletcher, and under the leadership of your successor that we can put those aside, and that this new National Space Policy Council will be a place to winnow out those kind of petty bureaucratic jealousies that we've seen in the past. Vast as space may be, it has no room for the narrow-minded and the shortsighted. And so I hope that everybody is going to team up in a sense of rededication and vitality, with this new sense of cooperation, to make space policy for the next several decades.

Now, today, we intend to look at the 1990 budget. This is the final budget submitted by the Reagan Administration, and in many ways it is as paradoxical as any budget request that has been submitted in the past. On the one hand, it contains a substantial increase of 22 percent above the last year. No other agency in the Federal Government has received such an increase of a magnitude as this.

But, on the other hand, it contains a recommendation to the Congress of major cutbacks and eliminates crucial research and development programs that we have supported in the past. There are also vague proposals to make private large portions of the space infrastructure with no serious plan for doing so. And I'll tell you, this committee is going to hold you guys accountable for this. We want some explanations. We need a great deal more in the way of information and dialogue if we are to act on these proposals.

Now, under the tremendous leadership of our full committee chairman, Bob Roe, we wrangled and harangued and cajoled and traded to get a multi-year funding in. We were successful in a multi-year authorization for the Space Station. That makes sense. On a major R&D you just simply ought not to do it year by year by year, but instead ought to look at it for many years, and we were able to get authorization for 3 years.

And, in the NASA authorization bill we also have written into law, we tried to get the requirement that NASA would submit to us a 3-year authorization for all of NASA. We had to negotiate long and hard on that. I give a great deal of the credit to Bob Roe for this, because he stuck in there, in the trenches, as he was in the process of the give and take in the waning days of the session, hammering out the final version of the bill. And what we got in the compromise was that NASA was to come with a 2-year authorization request with a third-year target. And we will eventually get the third-year authorization in the law.

But we have no 2-year request for authorization by NASA. We only have a 1-year request, and that is inexcusable. And this subcommittee is going to hold your feet to the fire to abide by the law when, in fact, the whole purpose for doing this in the first place is to help you.

So, Dr. Fletcher, we welcome you back. We thank you for your leadership. You've had one of the toughest jobs in Washington. Where we have differences we will certainly air them. But you know our appreciation to you for the dedication and respect, and we give you our unyielding respect in taking one of the toughest jobs under the most intense scrutiny under the time that America was knocked down. But, as a testimony to your leadership, America was not knocked out. And so we rejoice in the fact that we're back on track and we look forward to that continued leadership.

[The prepared opening statement of Mr. Nelson follows:]

OPENING STATEMENT

HON. BILL NELSON, CHAIRMAN

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS

February 2, 1989

Today the Subcommittee on Space Science and Applications begins its new business in the 101st Congress. I want to welcome the new Members of the Committee (Mr. Johnston, Mr. Tanner, Mr. Schiff). I look forward to an active and productive legislative year.

I also look forward to a year in which we can move the American space program ahead and prepare ourselves for the 21st Century in which space will play a major role. The Challenger accident is now well behind us and the Shuttle program is on its way to resuming a full-flight schedule. The tasks that lie ahead are challenging. We must establish an operating manned Space Station before the end of the decade; we must reinvigorate our space science program; and we must develop a stable policy climate that will encourage private sector investments in space. These things will not happen by themselves. They require the guidance and support of Congress and strong leadership by the President. This Committee intends to play a major role in this process.

On January 20th the American people welcomed its new President,
George Bush. With this new Administration comes a marvelous opp
address the weaknesses and shortcomings that have been evident
program in the past. The new President and the team he sel

the chance to forge a new beginning for our space effort. I look forward to a new era of cooperation between Congress and the Administration and it is my sincere hope that we can establish and work toward common goals for our space program.

We are long past the time when we can afford to ignore crucial space policy issues and permit our space program to languish in neglect. Our space effort is, by definition, one that requires new challenges for its very existence. It requires visionary goals if it is to be done at all, and most of all it requires the attention and leadership of its Chief Executive.

Space is a place. It is a place for new opportunities, it is a place for scientific and technological progress, and it is a place for achieving the American dream. Vast though it may be, it has no room for the narrow-minded or the short sighted. I hope that the President, the Vice President, the National Space Council and the other members of the new Administration's team can help us reestablish the vitality that will be needed to carry us through the next decade in space.

Today, we intend to take a first look at the Fiscal Year 1990 budget. This is the final budget submitted under the Reagan Administration. In many ways it is as paradoxical as any budget request in the past. On the one hand, it contains a substantial increase of over 22 percent above last year. No other agency has received an increase of this magnitude. On the other hand it contains major cutbacks and eliminates crucial research and development programs we have supported in the past. There are also vague proposals to privatize large portions of the space infrastructure with no serious plan for doing so. We will need a great deal more in the way of information and dialogue if we are to act on these proposals.

Today we also welcome back Dr. James C. Fletcher in what may be his last appearance before this Subcommittee as NASA Administrator. I sincerely hope, however, that we can continue to prevail on you for your advice in the future. Your experience has been a valuable asset to the space program and you have served your Nation long and well. I commend you.

I would now like to turn to our new Ranking Republican, Mr. Sensenbrenner, for whatever remarks he may have. I look forward to working with you in the bipartisan manner that has been the trademark of this Subcommittee.

Mr. Nelson. May I ask you for your opening comments? As you know, I have requested that it be in a conversational manner, because I have promised to my committee members this year that we will not have any boring presentations. [Laughter.]

I have promised to my committee members that we will not have people come and read a script which they can read. I have promised to our committee members that they are going to be participants in one of the most exciting endeavors that the United States can participate in, and that is our Civilian Space Program.

Please, Dr. Fletcher.

STATEMENTS OF DR. JAMES C. FLETCHER, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY DALE MYERS, DEPUTY ADMINISTRATOR; NOEL HINNERS, ASSOCIATE DEPUTY ADMINISTRATOR; TOM CAMPBELL, COMPTROLLER; LENNARD A. FISK, PH.D., ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS; GARY L. TESCH, DEPUTY GENERAL COUNSEL; FOSTER FOURNIER, DIRECTOR, PROCUREMENT MANAGEMENT DIVISION; GEORGE ABBEY, DEPUTY ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT; JAMES B. ODOM, ASSOCIATE ADMINISTRATOR FOR SPACE STATION

Dr. Fletcher. Thank you, Mr. Chairman. By way of greeting, I do enjoy discussing at length our program at NASA and in this particular meeting in the 101st Congress being able to tell you about our budget proposal for 1989-1990. I enjoy for this for two reasons. One is that we have a lot of good friends on the subcommittee membership and on the staff, but also I think we've got something to talk about this year. As a matter of fact, as the chairman indicated, we've got an exciting program ahead of us, and so I like to come with good news once in a while and this is the time for that.

In spite of the fact that I'm supposed to be entertaining—I'm not sure that's the word you used, but not boring—I'm not sure I can guarantee that, but I will do my best.

Let me just give you briefly the essence of the budget. It is, indeed, true that we have requested 13.3 billion, which is 20-some-odd percent above last year's approved budget; only 15 percent, by the way, above the President's budget last year, so it's not as bad as it might look. We were cut somewhat severely last year, as you suggested.

But that breaks down something like this. For R&D—we have these 4 line items, you know. For R&D—research and development—we have about $5.8 billion; about $5.1 billion for transportation, the so-called SFCDC; we have $2 billion for what we call "institution," but that line item is called R&PM, and this is very important, the institutional building, as part of the recovery from the accident; and then another $342 million for facilities.

Now this is, essentially, the budget that was last year's run-out. It's about 1 percent—it's really lower than last year's run-out. But of this work, only 1 percent of it is for new work, work that wasn't discussed with you last year; and of that 1 percent, only one new start, and that's the so-called CRAF/Cassini mission, which is a mission to the comets and the asteroids for one part of the mission, and then to the planet Saturn, similar to Galileo, for the second part. And that's the only new start.

Last year, when we presented you the budget we indicated that our first priority was return safely to space flight, and we've done that. We're not finished yet, though, because now we have to fly regularly, 5 times this year and 7 or 8 times next year, and then continue on up to 12 times a year when we get the replacement orbiter. But nevertheless, we're on the track for that space flight recovery.

We also have to continue the development of the Space Station Freedom, and I expect we'll have a lot more to say about that later, but it is our key to the future, not only for what it does in itself in building the space infrastructure, but for what it does to enable us to go and fulfill the mission of expanding human presence into the solar system.

It also continues the same pace that we started last year and the year before in science and aeronautics and space technology. Not quite at the level, as you've suggested, that we had hoped for Pathfinder, but nevertheless a substantial increase over last year.

It also tries to keep our core technical capabilities, which really is what makes NASA different from most other government agencies, dynamic as well as productive. And the entire fiscal 1990 budget encompasses those 4 items.

Now, I don't have to say it again, maybe I say it too often, but this is a very tight budget, and, as you well know, it's a tight budget year. We've got a deficit problem which is not trivial, and we've had to accommodate a large number of reductions from what we think is a truly aggressive space program. And I'm sure we'll hear from you about some of the things that we left out that should be in there.

One aspect of it you already mentioned has to do with private sector investment. This is an initiative of the Reagan Administration, and it's not new with us. It's not only with us in the fiscal 1990 budget, it deals with bridges and airports, and even EPA has some of these initiatives. We've tried to pick out the ones that we think are viable, and we'll, I'm sure, have time to discuss that later.

But the important point I want to make is there's $200 million worth of those, and if we don't get permission, authorization from you, particularly for termination liability, if we go ahead with these, that means $200 million that comes out of the budget. And I doubt if anybody in this Congress is going to increase our budget very much with the 20-some-odd percent that you mentioned. So it is important to mention that, and we did need your help in pushing those private initiatives forward. But, of course, we'll have to justify them and explain them adequately to your satisfaction.

We do, I do want to apologize for not meeting the 3-year budget that you requested last year right up front. We didn't do it. You asked us to do it. We got into a bind. And the late passage of the bill, it was kind of late in the congressional cycle, and also the early requirements in OMB to get a budget together, the earliest we've ever done it in my, in the history of my 2 tours, we just weren't able to negotiate all of the out-year new starts.

And we do have a run-out for the 3 years—the 2 years following fiscal 1990, but it does not contain new starts. It's hard to get approval. There's a lot of negotiation required for those new starts. And I must say that we made a start at it, and, by the way, the Administration is supportive of your thought. They're on your side on this one, and I believe that they, they will support in the future multi-year budgets but there needs to be a much bigger effort than we were able to mount last year to provide a decision process, a decision-making process that will accommodate such out-year funding.

We really have to negotiate new starts 3 years in advance. That's not an easy thing. But I think we'll do it next year. We're going to get a running start now that we have the legislation and now that we know the Administration, the Reagan Administration anyway, has signed up to that principle. But, again, as you say, we weren't able to do it.

Now finishing up, the challenge for NASA and the entire Bush Administration, the Congress, and also the American people, is to keep this integrated program on track. But I would like to say one very important thing again, and I'll say it again and again: if we aren't willing to commit the energy and the will and the money that this program requires, we're not going to succeed in this program. You can't have a first-class program by investing second-class resources. And it's national investment that is at stake here, investment in humanity's future, in America's right to influence and to guide that future, and we don't want to fall short of a deserved expectation that the Nation has that we all serve.

Thank you very much, Mr. Chairman.

Mr. Nelson. Dr. Fletcher, thank you very much.

[The prepared statement of Dr. Fletcher follows:]

Statement of

James C. Fletcher
Administrator

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science, Space and Technology

House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittee:

I welcome this opportunity to discuss the FY 1990 budget request for NASA as submitted by President Reagan.

Overview

With the help of this Committee, as well as the other Committees that review our budget and the Congress as a whole, the Nation's space program is making a strong recovery. The shuttle is flying again, the replacement orbiter is well into production, and the space station is under development. A number of key science missions are about to fly. And the mixed fleet is a reality. In short, the space program is back on track. The challenge now for us in NASA, for the new Administration, and for you on Capitol Hill, is to keep it on track to sustain and build on the forward momentum toward our long-range goals in space.

We have had two successful shuttle flights, but only two. We still have many flights to go to reestablish full confidence, demonstrate reliability, and work off the backlog of scientific and national defense missions.

We have made a strong beginning with the Space Station Freedom Program. We have Congressional approval, we have a firm configuration, contractors have been selected and are at work, and formal agreements with our international partners are in place . And now, the real work of design, development and testing has begun.

Our science programs are in good shape, with several major projects awaiting their turn for a shuttle launch. The FY 1990 budget continues to provide strong support for space science.

Our studies toward long-term expansion of human presence and activity into the solar system are progressing, but we still have much to do before we fully understand the potential options, benefits and costs.

We are on the track laid out in the national space policy enunciated by President Reagan and in the FY 1989 budget. Your support - the actions of Congress last year - made it possible for us to move ahead without major programmatic changes. This FY 1990 budget request includes $13.3 billion for NASA, approximately $1.8 billion more than last year's request and $2.4 billion more than the FY 1989 appropriation. This is slightly less than the amount forecast a year ago when we presented the FY 1989 budget to you.

Virtually all of this increase is needed for programs presented and approved last year:

- the step by step build-up of space shuttle flight rate and development of the Advanced Solid Rocket Motor;
- the continued development of the space station;
- the Science and Applications, Aeronautics and Space Technology programs; and
- the necessary supporting activities

The fact that President Reagan approved this substantial increase in NASA's budget is strong testimony to the validity of the need and to the national importance of NASA's programs in space and aeronautics and the technologies they develop. In looking at the details, you will see the FY 1990 budget of $13.3 billion affirms this strong support for the space shuttle, the space station, space science and technology and aeronautics.

Let me highlight some of the key areas of this budget:

Space Transportation

Space Transportation activities - including the shuttle, upper stages, expendable launch services, spacelab and payload operations and related activities - will require nearly $4.7 billion in FY 1990. Our top priority goes to steady, long-term recovery and return of the shuttle to safe and reliable flight.

In the space shuttle, we have the world's most advanced system for getting people and payloads to and from Earth orbit, for carrying out U.S. scientific research in space, for stimulating commercial ventures, and for accomplishing many tasks in orbit, such as retrieval and repair of satellites, that cannot be done any other way. We sometimes forget the exciting and important missions already accomplished using the shuttle - the launch of major communications satellites, on-orbit repair of the Solar Maximum spacecraft, retrieval of defective spacecraft, and four major Spacelab missions. Indeed, these sophisticated missions are a testament to how much has been accomplished by the shuttle on 26 successful flights. At the same time, we must remember that this remains a complex developmental vehicle which will continue to require an extraordinary level of care and attention.

NASA's return-to-flight effort paid off with two successful flights in 1988 and, more importantly, with a revitalized shuttle fleet that is scheduled to deliver the more than 60 shuttle missions planned through 1994. Five shuttle flights are scheduled for FY 1989, followed by nine flights in FY 1990. The mission plan includes:

- the third Tracking and Data Relay Satellite, to be launched on the next flight;
- the Magellan mapping mission to Venus;
- the Galileo mission to explore the Jupiter system;
- the retrieval of the Long-Duration Exposure Facility;
- the Hubble Space Telescope, the first of the Great Observatories in Space; and,
- a Spacelab mission devoted to life sciences.

These missions scheduled during the next two years are just the beginning. For example, the longer term flight plan involves 23 Spacelab missions and many more missions important to science and to our national security.

The shuttle is the fundamental link in a space transportation infrastructure which will carry this Nation into the 21st century. It is our means to place human beings into orbit and it makes the Space Station Freedom possible and practical.

The FY 1990 budget provides the funding necessary for shuttle operations to support the planned missions and to proceed with the development of the Advanced Solid Rocket Motor to enhance the safety, reliability and performance of the shuttle. It provides funding for expendable launch services for scientific and operational payloads including the Global Geospace Science missions and the Mars Observer. In addition, the budget provides for the related Space Transportation Capability Development activities detailed in our budget request.

Space Station Freedom

The budget provides $2 billion to continue the planned build-up in funding for significant expansion of the development of the space station. The bulk of this funding will go to the four work package contractors to support detailed design activities. The development plan and basic configuration are firm, and the development contractors are making substantial progress. We are moving toward a first-element launch in early 1995 with a capability for man-tended research activity by the end of that year and a permanently manned capability by the end of 1996. Our international partners are committed, investing their resource and working on schedules consistent with this plan and with the agreements approved last fall.

Space Station Freedom is the best space station to meet our national objectives in Earth orbit and to support our long-term goals of expanding human presence and activity into the solar system. The space station is of the highest importance to the future of the civil space program.

In simple terms, Space Station Freedom is:

-- for science and technology,

a permanently manned research laboratory in space - where advanced research equipment and human intelligence can interact on the spot, where we can learn about the Earth's changing environment, and a place to learn about long-term human activity in space;

-- for human exploration of space,

a gateway for integration, test and departure for potential future missions; for human exploration of the solar system, all roads will pass through Space Station Freedom; and,

-- for international cooperation,

a clear, visible symbol of our commitment to peaceful leadership as a space-faring nation and of our readiness to cooperate with other nations in this great adventure.

Space Station Freedom is clearly the next step in the involvement of human presence, human intelligence and, most importantly, the human spirit, in the exploration and utilization of space. That is why it is so important that we move ahead with development of Space Station Freedom. Other nations have certainly recognized the extraordinary value of the experience of a permanent human presence in space; the Soviets assuredly have acknowledged it and have already committed major resources to bring it to fruition. Without the space station, this Nation would need to reexamine fundamentally its goals and objectives for the civil space program.

Space Science and Applications

Nearly $2.0 billion of the budget request for FY 1990 is planned for the Research and Development activities managed by the Office of Space Science and Applications. These important activities are, of course, directly supported by other elements of the NASA program - particularly Space Transportation and Tracking and Data Acquisition.

For more than 20 years, the Space Science program has been extending our vision and expanding our understanding of the solar system, the galaxy and the universe, and it has given us a new way of looking at and understanding the Earth. Only from space can we observe the Earth on a global basis.

The Science program is on the verge of a new era with the resumption of flight activity on both the shuttle and expendable launch vehicles. By the end of 1990, we will have launched the Magellan mission to Venus, the Galileo mission to Jupiter, and the Hubble Space Telescope, the first of the Great Observatories. In addition, we will have launched the Gamma Ray Observatory, the Cosmic Background Explorer, the ROSAT, and the Ulysses mission to look at previously unreachable areas of the sun. We will have flown an important Life Sciences Spacelab mission. We will be developing the mirror for the Advanced X-Ray Astrophysics Facility (AXAF) and instruments for the Global Geospace Science mission. The FY 1990 budget proposes initiation of the Mariner Mark II spacecraft missions (CRAF and CASSINI) to expand our knowledge of comets and of Saturn and its satellites. CRAF/CASSINI will study the material from which the solar system formed, the material from which life formed, and the chemistry which gave rise to that life.

The Applications program applies space capabilities to the Earth and its environment, to materials processing, and to communications and information systems. More than $400 million is proposed in NASA's FY 1990 budget for spacecraft, instruments, research and analysis relating to our Earth's environment and climate. Development of the Upper Atmosphere Research Satellite will be nearly complete, and we will be well underway on our portion of the international TOPEX Poseidon ocean monitoring satellite. We will be defining the next major Earth Observing System. The proposed budget provides for continued development of new equipment and experiments to take advantage of the microgravity environment. The space station microgravity environment offers a unique promise for research and development in new materials, medicines, and processes which are beyond our present capabilities on Earth.

Aeronautics

For our Aeronautical Research and Technology program we are requesting $463 million in the Research and Development program. This may well be the portion of our budget that yields the highest return.

Since the early days of aviation, the technology developed by NASA and its predecessor - the National Advisory Committee on Aeronautics - has been a major factor in the preeminence of this Nation in atmospheric flight - both in military aircraft and in civil transports. Today, the aircraft industry is the leading contributor to our balance of trade, providing a positive contribution and a favorable balance of $16.8 billion last year. Eighty-six out of every hundred civil transports in the world today were built in the United States. More than a million Americans earn their living in aeronautics. Clearly, our Nation is the world leader in aeronautics. We need to keep it that way.

Our FY 1990 budget covers a comprehensive program of Aeronautical Research and Technology to:

-- address the critical issues associated with the U.S. air transportation system;

-- enhance U.S. competitiveness in the international market place;

-- preserve our preeminence in aviation for the security of the Nation.

We will be focusing on technologies to enhance aviation safety, efficiency and performance across a broad range of vehicle applications. We will begin a new thrust in high-speed research with emphasis on the critical environmental issues of atmospheric impact, sonic boom and airport noise.

Our future place in world aviation depends on the research and technology work we do now.

Transatmospheric Research and Technology

The FY 1990 budget includes $127 million for NASA's share of the National Aero-Space Plane program effort to develop the technology to take us beyond present atmospheric flight capabilities into the realm of hypersonic, transatmospheric flight. NASA efforts are aimed at accelerating development of the critical materials, propulsion and control technologies which could enable a new class of vehicles in the future capable of flight to orbit as well as hypersonic flight between points on earth.

Space Technology

For FY 1990 we are requesting $338 million for Space Research and Technology Activities. It is now taken for granted that man can fly into space, conduct exciting missions, see deep into the universe, observe the Earth as a global system, and watch events around the world in real time on our television screens. A lot of hard work in space research and technology over many years has enabled these capabilities. But, continued focused effort is required to realize future possibilities -- not only in space, but also to maintain and expand the Nation's technological base.

We have drawn heavily from technology developed in the past. NASA is working on technologies for the future, but the many knowledgeable groups which have reviewed our program have been essentially unanimous -- we need to strengthen our efforts.

We are moving to do that:

-- NASA's basic program explores fundamental technology in newly emerging areas which offer promise of longer-range, high-leverage benefits;

-- the Civil Space Technology Initiative focuses on the technology needed to enhance our near-earth capabilities including automation and robotics, information systems, propulsion, power, and large structures in space;

-- the Pathfinder program is developing new technologies needed for potential expansion into the solar system - major studies include surface exploration, in-space operations, humans in space, transfer vehicles, and mission studies; and, -- a new thrust is included to extend technology development to in-space experimentation using the shuttle and ELV's now and, later, the Space Station Freedom

Our mission study activities focus on possible future human exploration out into the solar system. The studies are examining mission design options including possible use of the Moon as an observatory base or for using lunar resources at a Lunar base, or possible piloted missions to Mars and its moons.

Tracking and Data Acquisition

None of our space flight programs could meet their objectives without the availability of high quality, reliable space operations, tracking and data support. Our FY 1990 budget includes $1.1 billion to assure that support now and in the future. The transition from a ground-based tracking network to a space-based system for low-Earth orbit missions is continuing with the launch of the next Tracking and Data Relay Satellite spacecraft (TDRSS). The budget continues this activity including replacement of the TDRSS lost in the Challenger accident to ensure continuity of service through the mid-1990's. The budget includes procurement of equipment for a second TDRSS ground terminal which is critical in order to eliminate the present ground terminal as a single point of failure, and to provide the capability of operating more than two TDRSS in orbit, as well as it being important to future system operations and reliability. The budget also provides for operations and improvements of the Deep Space Network to support the upcoming planetary missions.

Commercial Programs

The FY 1990 budget request includes $61 million for the Commercial Programs' Office activities. During 1988, agreements were completed to fly the Spacehab microgravity facility on the Space Shuttle and with the University Corporation for Atmospheric Research to use the Space Shuttle external tanks. NASA also signed launch support agreements with several expendable launch vehicle manufacturers. The FY 1990 budget provides for continued improvement of the Technology Utilization Network System which facilitates timely and effective communications among the Industrial Applications Centers, the Technology Counselors, and other NASA Technology Utilization offices. We plan to establish links with other networks in FY 1990. The budget emphasizes the development of ground facilities and equipment to expand the NASA technical research data base used by the private sector. The FY 1990 request also includes funding for support of sixteen Centers for the Commercial Development of Space.

Safety, Reliability, Maintainability, and Quality Assurance

The FY 1990 budget request of $23 million supports the aggressive implementation of the NASA Safety, Reliability, Maintainability, and Quality Assurance program. This effort will pursue the strengthening of the execution of NASA programs through continued introduction of systems to provide Agency-wide independent assessments, problem reporting, failure analyses, corrective actions, trend analyses, in-depth safety reviews, and nondestructive evaluations.

University Space Science and Technology Academic Program

This new budget line item of $35 million provides for continuation of Agency-wide university and minority university programs previously budgeted in other NASA programs. FY 1990 funding will support graduate and undergraduate student fellowships, faculty fellowships, the historically black colleges and university research program, other minority universities, and the Space Grant College and Fellowship program.

Private Sector Investment and Involvement

An important thrust of this Administration policy and the FY 1990 budget is increasing the participation of the private sector in space -- not simply in performance of work, but in financing new activities and in accepting some of the risks, as well as sharing in the benefits. In accordance with the National Space Policy, the FY 1990 budget encourages greater private sector involvement in meeting the Nation's space goals. During the coming year, one of NASA's major efforts will be to seek increased private sector investment and involvement in space.

With respect to the planned space infrastructure, we have identified, as candidates for private investment, portions of the development of extended mission duration capabilities of the Shuttle; the development of the space station Flight Telerobotic Servicer, solar dynamic power, and a docking module for the Space Station, and future requirements for the Space Station, including those under study. The budget plan includes Government use of a commercially developed space facility (CDSF), with funding beginning in 1992. In ground-based facilities, the proposed budget includes seeking private financing for facilities for processing the space station, for neutral buoyancy training of space station astronauts, and for R&D on observational space instruments. NASA will develop specific procedures and criteria for commercial development of space-related systems including the space station and other manned space flight systems.

Timely success in this endeavor is essential to allow the program to work within the proposed budget level; it is crucial that NASA be in the best position possible to explore private opportunities in a timely fashion, so these vital elements of the Space Station program and important Shuttle improvements can move ahead on schedule. NASA's proposed FY 1990 authorization bill will be transmitted to the Congress in the near future and will address this issue. It is important that Congress act quickly to consider this authorization bill which will address the issue of termination liability for private sector investment in these critical areas.

NASA Capability

A major priority of the FY 1990 budget request is the continued assurance of the health and strength of the NASA institution, on which the Nation has relied so heavily for nearly thirty years. The FY 1990 budget proposes $341 million for Construction of Facilities and $2.032 billion for Research and Program Management. As you know, the Research and Program Management pays for our civil service personnel - the researchers, scientists, engineers and managers - for their travel, and for the basic operation of the NASA institution. The key element in all NASA programs - past, present and future - is, in fact, our people. The budget proposals for 1988 and 1989 recognized the need to revitalize and invigorate the NASA workforce and facilities. The 1990 budget continues this thrust.

While I believe that NASA still has a superb work force, possibly the best ever assembled, the Agency must work constantly to keep it that way, with a focus on quality and on the needs of the future. We need to balance our experienced scientific and engineering work force through people with new ideas and concepts. The Nation's future in space and aeronautics depends on a dynamic, competent core technical capability at the NASA centers. At the same time, NASA must strengthen its management capabilities - the ability to deal effectively with highly complex program engineering and integration requirements involving activities throughout this country and abroad. In addition, NASA must provide appropriate facilities and equipment commensurate with our research and development objectives.

Therefore, the proposed FY 1990 budget reflects as a high priority the necessary funding for people and facilities. The Research and Program Management budget provides an increase of 700 people over FY 1989 level. NASA needs those people, and we intend to acquire the best people available to meet NASA's needs now and in the future. The Construction of Facilities budget request accommodates critical requirements supporting the Space Station Freedom program, necessary space flight improvements, advanced aeronautical research and the Aeronautical Facilities Revitalization Program.

Summary

In summary, the FY 1990 budget request approved by President Reagan proposes the following:

Research and Development	$ 5.752	billion
Space Flight Control and Data Communications	5.140	billion
Construction of Facilities	.342	billion
Research and Program Management	2.032	billion
Inspector General	.009	billion
TOTAL	$13.274	billion

I believe that this FY 1990 budget proposal reflects the fact that the space program is back on track. The content of NASA's program is solid, productive and exciting. I must caution you, however, that this is a very tight budget. NASA can only accomplish the objectives, and the programs outlined, if it has full support all the way through the process. We are prepared to give it our best shot -- and we are counting on the support of the Administration, the public, and especially the Congress.

Mr. **Nelson**. I'm going to reverse the normal order and the chairman is going to defer his questions, say, for one, so that I can go on and have our members participate and ask questions.

But I just, before this question I want to tell you that those who are advising you that the process of the adoption of the legislation was late, as it was signed by the President in October, and that does not meet—November the 17th, that does not meet your ability to negotiate with the Office of Management and Budget simply are not advising you correctly. Because this bill was marked up in this committee last April and it contained that. It contained the multiyear authorization, not only for the Space Station, but for all of NASA. It was passed through the full committee, and it was passed through the entire House of Representatives as it went to the Senate. So there was plenty of advance notice as to the legislative intent of what was simply trying to help you.

We did this, certainly, with input from you specifically, and you generally as an organization, in trying to make more sense out of the chaos that we have seen in these fits and starts of 1-year cycles of budgeting for massive R&D projects. And so that answer just simply is not acceptable, and waiting until next year's budget cycle, fiscal year 1991, is certainly not acceptable.

And so what we would request, and I understand your position. You're between the rock and the hard place, Dr. Fletcher; and that's the trouble, that you've been there too often in the past between all these other guys who are trying to make the decisions. And so we just want you to know clearly the intent of this committee is that we're awaiting the second-year authorization request from the agency, and we will continue to await and we would appreciate your advice on when it's coming and so forth. Because the recommendation on your decisions, the hard choices that you're talking about, is precisely what we have to make as we make the choices of the upcoming dollars and how they're going to be allocated, and what's going to get funded, and given the deficit crisis and all of that. So we need, and we need that third year as well, even though it's not an authorization under the law, it is the budget estimates for the third fiscal year. So we await that.

Dr. **Fletcher**. Mr. Chairman, I accept your criticism. I wouldn't want to blame it on the staff too much. We did make a run at it in the time that we had left. We probably were late in trying to do that. But it is not a trivial problem to debate these new starts, and we have a fair idea what they might be in 1991, but to pin them down is another thing again.

We'll try to be more responsive in 1991, and perhaps we can do something before that.

Mr. **Nelson**. Well, we need it this year as we are making the choices for fiscal year 1990. They're going to be directly affected with regard to what your requests are for 1991 and 1992.

And we are just asking you to comply with the law. May I remind you that that law was—that legislation was signed into law by President Reagan, and, so when you start haranguing with the budget chiefs over there remind them of that fact. And basically, we're just going to sit. We're going to sit. We're going to sit on our hands until we get it. So I hope that you will be forthcoming there.

Now, just respond to this. Secretary Verity in an article of January the 11th, USA Today, is quoted as saying that NASA is a bloated bureaucracy deterring industry from operating in space. He said that the space agency should stop running a "glorified trucking operation" and return to its original purpose. He says, "A great oversimplification"—oh. That was a response from Bert Edelson, who was responding to him. [Laughter.]

Good old Bert. [Laughter.]

Why don't you, for your opening salvo, give us some comments about former Secretary Verity's comments?

Dr. FLETCHER. Well, since he's former and I'm still here—[Laughter.]

I think that was a misguided speech from the first. The adjectives and so forth I think were ill-chosen, and what's worse is that some of the facts were not straight. And at the time I didn't feel like I should respond in a long statement. That would only continue on the debate or the controversy. I think we've got a first-rate Secretary of Commerce now and I think we'll be working with him to solve some of the problems.

With regard to the "glorified trucking operation," well that's just a complete misnomer and you know that better than I. We've been working on that so-called "glorified trucking operation" for 3 years trying to get it back working. It's a highly technical, highly R&D, highly risky business, and we aim to make it as safe as we can, but it's still going to be a big risk. And some people are willing to take that risk, and I applaud them for it. But it is not routine.

The rest of the statement I'll be glad to comment on in detail if you ask it, but it was full of errors. And I think it's most unfortunate, because Secretary Verity is a nice man, and I can't imagine why he made such a speech.

Mr. NELSON. Well that's been part of our problem in the past, of getting this cohesiveness. And we're going to look forward to a much improved space policy decision-making in this coming year.

I'm going to call on our committee members in the order in which they arrived.

Mrs. Morella. Mr. Volkmer.

Mr. VOLKMER. Thank you very much, Mr. Chairman.

I have several questions, Dr. Fletcher. One is that I have some concerns with the proposed budget, and I'm sure many other people do, too, and I want to try and touch on all of those in the limited time each of us has.

In this proposed budget we see a reduction of $50 million for structural spares. As one who was subcommittee chairman back when we started the original program of spares they're now leading to our replacement orbiter. I feel that this is an area which we better start now and not wait another year because of keeping the lines open, the tooling, et cetera, from what I've understood now.

I also understand that right now we're under about $50 million under on costs on that replacement shuttle for this year, and we may end up with that, around that figure. Now that figure is going to still be in NASA's hands, is it not, that 50 million, if we do?

Dr. FLETCHER. I'm not sure about the numbers, Mr. Volkmer. We are running a little bit behind schedule and we're ahead on cost and I hope that there is money left over, but we would like to keep some of that for emergencies. We need an adequate margin. But nevertheless, your point is well taken. I'm just not sure of the number.

Mr. Volkmer. Let's assume that we have a number, whatever that number be. Would you have any objection to using that number for replacement?

Dr. Fletcher. Well, let me start by saying I think, really, you were on the right track when you said we ought to get going with the structural spares. And as you know, we had adequate money for structural spares earlier that we had to use for the replacement orbiter, and this money was an attempt to get back those structural spares. We will try to do that as soon as possible, and I think within the limits of what we can and can't do with that orbiter money—I'm going to ask Mr. Campbell to comment on it—we will take a look at that possibility.

Tommy.

Mr. Campbell. Yes. We have $15 million in, as you say, just to sort of pull the program together.

Mr. Volkmer. You're not going to build much with 15 million, you know that as well as I do.

Mr. Campbell. That's correct. And we've taken steps to pull the tooling in from some of the major vendors into Rockwell——

Mr. Volkmer. I understand that's been done; yes.

Mr. Campbell. The question of the status of the replacement orbiter is that it is in excellent shape. It probably is—the reason for it, or major reason for it is that we got full funding——

Mr. Volkmer. Right.

Mr. Campbell [continuing]. And we're able to conduct the building of this orbiter on a very, on a straightforward, well-planned and well-laid out production schedule and hold to it.

We have already, however, adjusted the original value, as you may know, by over $200 million. You know, we've transferred $225 million out with the, at the direction of the Congress, into other programs. Our concern at this point is that we have a substantial number of potential changes to the orbiter that await process and approval, and it's over $100 million, and we really need to get a better fix on the progress on it relative to the other.

And I think the figure used in the interim may be a little optimistic. Our assessment is we are underrunning, but I don't think our assessment is that it should be begun at this point. So, while we could apply that with the agreement of the Congress to structural spares, and it would be a good investment for us to do that, we are a little cautious about it at this point in the production schedule.

Mr. Volkmer. Well, then, but you agree that we should start down the road for structural spares, do you not?

Mr. Campbell. Yes. We're preserving that option, and it is a significant——

Mr. Volkmer. But you're not really starting it.

Mr. Campbell [continuing]. Cost, as you know. It's $500—no.

Mr. Volkmer. Wouldn't we better off, though, if you had the money so that next year you'd be able to go out and contract and start for the wings and the pods and the mid-fuselage and all those things?

Mr. CAMPBELL. Well, it would be the best position for the agency to be in if we had the budget level that we went to OMB with. But, as you know, we have absorbed substantial adjustments, and this was one, the structural spares was one of the adjustments. And we really have to examine the total program before committing to the next fly of the structural spares.But that puts you in an excellent position to build a future orbiter or to have spares available for impact or damage to the fleet.

Mr. VOLKMER. That's true. Sure.

Mr. CAMPBELL. So it would help to get a robust fleet, yes.

Mr. VOLKMER. If we have something occur to the 3 that we now have——

Mr. CAMPBELL. That is correct.

Mr. VOLKMER [continuing]. To some of the major parts, we got a long time down time, do we not?

Mr. CAMPBELL. That's correct.

Mr. VOLKMER. That's what I'm—I know——

Dr. FLETCHER. Mr. Volkmer, I think you're on the right track. I think if we had the money we would have had more like 60-some-odd million for structural spares. That was the track we were on.

Mr. VOLKMER. Yes.

Dr. FLETCHER. But, as we discussed earlier, we had to squeeze this budget down.

What we've done, and I think you referred to it, is we kept the subcontractors alive with that 15 million, and that's the right thing to do if you only have 15 million. So we're not doing anything except delaying the date on which we receive those structural spares, and I think that's a reasonable thing to do if you start getting squashed on your overall budget.

And, of course, judgment is required here, and we made the judgment that we could slide that program somewhat. We are going to have those structural spares.

Mr. VOLKMER. Perhaps we can work together to maybe work something out on this, get something done worthwhile. Meaningful, let's put it his way. Not worthwhile, but meaningful. Get some money in there.

The other area that I'd like to discuss—if you wouldn't mind, Mr. Chairman, a few brief moments. As I understand it, there has been a request for information put out now on the CDSF. Is that correct?

Dr. FLETCHER. That's correct. Yes.

Mr. VOLKMER. In light of the committee's action last time, and waiting now for the review—I call it a study—and a report that will be given to us in May, you will not take any action beyond that before we're able to review?

Dr. FLETCHER. Mr. Volkmer, that's not our plan. We plan to go down the track that you proscribed for us last year. We felt that the Request for Information that we sent out would help us on that plan.

Mr. VOLKMER. I'm not disagreeing with that. I'm just saying further on. Right.

Dr. FLETCHER. We have no plans to do otherwise.

Mr. VOLKMER. I just want to mention that because some of us still have some concerns about the "need" for the CDSF, and I'm sure we all want to review it more thoroughly before we proceed with it.

Thank you, Mr. Chairman. Wait a minute. I have one other quick one.

Mr. **Nelson**. Sure.

Mr. **Volkmer**. In light of what the chairman brought out about long range goals and how do we get there from here and a 3-year authorization, et cetera, budget cycle and everything, and the stops and goes and those type things remind me—just like right now we've got the question on the Pathfinder. That reminds me of taking 2 steps forward sometimes and 1 step back, and then taking a look, and then maybe we take it next year a step and a half and a half step back the following year.

You understand——

Dr. **Fletcher**. I understand, Mr. Volkmer, what you're saying, and that's what we did. We don't like it, and I'm not sure our judgment is always the wisest but it did seem to us that we had to cut somewhere and we didn't—we have a substantial increase in Pathfinder over last year, and you tend to want to cut the new programs rather than to cancel old programs, which are almost already paid for. And so, by and large, that's the procedure we use.

On the other hand, I don't want to make any excuses. We do have a substantial amount of money in for not only Pathfinder, but for CSTI, which was the initiative we started the year before last. It's the civil space technology initiative. And so we are going down that track of building up, building back our Nation's space technology capability.

Mr. **Volkmer**. But, of course, that—what we're doing actually is you're extending the time which it's going to take to do that.

Dr. **Fletcher**. That's correct.

Mr. **Nelson**. Thank you, Mr. Chairman.

Dr. Fletcher, you're awfully sparse in this budget on spares, aside from the question of structural spares, and the guys who process this vehicle, anybody will tell you that. And you've had an opportunity to get around and you might just seek some more information of that as we go throughout our deliberations.

Now, with regard to what Mr. Volkmer has raised on the question of structural spares, either we're going to have to provide the structural spares that ultimately would lead to another orbiter and give us the backup that we have to or else we're going to have to have a new design of something that's a different variation, and, basically, we need to go on and make that decision.

Recall 4 or 4 years ago it was this committee that kept saying—as a matter of fact, Mr. Volkmer was chairman during part of that time. It kept saying we've got to have those structural spares. We've got to have those structural spares. And it's a good thing that we did. Otherwise, we would be another 2 years beyond the time that Challenger's replacement is going to be completed.

So what we need is, we need to make a decision. And of course, we can't make that decision. We've got to be advised by you. We provide the money. But we can try to help you focus as to why the need is to make this decision. Now, if the decision is that you're going to go with, ultimately, another kind of orbiter that's akin to what we have here, then we need to provide you some more structural spares. On the other hand, if it is that you're going in a different direction with some new hybrid, something else, then we need to do that. But that decision needs to be made.

Dr. Fletcher. Mr. Chairman, I think we've made that decision. If we go for another sixth orbiter in the next several years, it will be essentially the same as the OV–105 which is now being built. Now, with all the improvements, of course, that we've put into the OV–1, 2, 3 and—OV—all the other earlier ones, and that decision really has been made.

What I can't do at this point is say when we are going to start a sixth orbiter. I have said publicly before—my new boss may slap my hand for this, but I got slapped the last time for mentioning the sixth orbiter, but we really ought to be planning for another orbiter, as you have discussed. And I think we ought to have the structural spares in place at about the time we made the decision to go for that additional orbiter. And I think we're on that track, approximately. I don't think we've done anything to prevent us from doing that at this point. Although, again, we're not perfect; we make mistakes, but I think we're pretty much on that track, Mr. Chairman.

Mr. Nelson. Well, a budget request of $15 million—$50 million doesn't indicate that that's—that we're on that track.

Dr. Fletcher. Well it is primarily for the subcontractors. We didn't want to lose the vendors and the subcontractors, because those are the people that disappear first. And so, and we can't use it, really, too well with our prime contractor because he is busy building the orbiter. The reason for doing it earlier was to have structural spares available. Not for the sixth orbiter. That has not been part of our publicly stated plan, and is still not part of our plan in this Administration, although I haven't discussed it, of course. So it was to provide structural spares in case something structurally broke, and that was why we had the earlier dollars.

I think the dollars we have in there now will give us, will keep the program alive and viable and in a position to build another orbiter if that is decided to be the case.

Mr. Nelson. Mr. Smith?

Mr. Robert C. Smith. Thank you, Mr. Chairman.

I apologize to you, Dr. Fletcher. I have to leave in a few minutes for another meeting, but I do have a comment and a question.

Mr. Chairman, you used the term "paradox," I believe, in your opening remarks about the budget, and to pick up on what Mr. Volkmer said, I—to see a budget with a 22 percent increase—and I support the increase; I'm not saying that in a negative way—and then to see such minimal amounts in there for such things as spare parts just seems to me—the chairman called it a paradox—inconsistency, maybe you could go even further and say, I don't know. How would one plan a budget of a program like the Space Program and not even budget minimally acceptable amounts of money for the spare parts to continue the program? So that's the first point. And then, and just a follow-up, and then you can, please, respond.

Have you had any consultation with the Bush Administration, with the new people, on this issue or any other issue regarding changes in the space budget?

Dr. **Fletcher**. Let me take those one at a time, Mr. Smith. We, I think we, maybe, misled you a little bit when we talked about structural spares. We have a substantial amount in for spares for the Shuttle. I think it's 300 million or thereabouts, so we're not neglecting spares. It's just the structural spares; that is, the wing parts and fuselage and so forth. Those are the things that cost a lot of money.

And it's probably true, as the chairman said, that we're a little short of spares, but we manage. In fact, we're much better; much, much better than we were before the *Challenger* accident. We have a pretty good system for replacing the spares. We've put more money into the spare parts, and it's what we would call a marginal but adequate spare part program. So the spares are a different issue than the structural spares. Structural spares, there's a dual purpose there.

Mr. **Robert** C. **Smith**. Right.

Dr. **Fletcher**. And I think Mr. Volkmer was properly describing the other purpose. Sure we'd like to have more money for spares. It would speed up the operation some. But we haven't really been—resorted to some of the tactics—I don't want to say tactics, that's kind of a misleading—the kind of practices that we had before the *Challenger* accident in cannibalizing other orbiters and so forth. We would like to have more money for spares, but within the context of a squeezed down budget I think that $300 million is an appropriate amount.

Mr. **Robert** C. **Smith**. Using your term with my statement, the term "cannibalize," is the Space Station cannibalizing other portions of the space projects, in your opinion?

Dr. **Fletcher**. Using cannibalizing, Mr. Smith, in a different context. Our very high priorities is to get the——

Mr. **Robert** C. **Smith**. Taking dollars away, let's put it that way.

Dr. **Fletcher**. Yes, I understand what you're saying. We'll try to not only preserve intact the Space Shuttle with all of the safety requirements but to actually make improvements to it, both in performance and in reliability and safety, and I don't think the Space Station has substantially compromised that. There are some things we would like to do with the Shuttle or the STS—NSTS, as we call it—that we're not doing, and we could discuss those sometime. But I think it's adequately funded, with the possible exception of what we call allowance for program adjustment.

It's kind of skinny in terms of the kinds of emergencies that we just had, for example, on the engines. We suddenly found some cracks in the turbopump engine bearing case and we had to go back and redo them. But we allow those kinds of things, and we're a little bit skinny on APA but, nevertheless, I think the Shuttle is adequately, but not amply, funded, if you know what I mean.

And the Space Station is impacting on all of NASA's budget, but I think less on the Shuttle than any other part of the program.

Mr. **Robert** C. **Smith**. What about in the science, in the, you know, probes——

Dr. **Fletcher**. I think in the science——

Mr. **Robert** C. **Smith** [continuing]. The deep space probes?

Dr. **Fletcher**. Mr. Smith, on the science program, we try to keep that more or less in line with the idea of 20 percent of our R&D

plus Shuttle cost, and I think we've kept more or less to that figure.

What has been compromised more than I would like is in the new technology, aeronautics and space technology areas; and Pathfinder was mentioned, but that's an example of the kinds of things that Space Station and Shuttle have cut into. We think there ought to be more money for those programs.

Mr. ROBERT C. SMITH. I don't want to beat it to death, but it just seems to me, again using the term "paradox," that to be by everybody's admission here apparently underfunded in at least the structural spare parts and certainly underfunded in R&D, and with that 22 percent increase, it just seems to me that the priorities are wrong somewhere. And I guess back to my original point, just a quick response. Do you—have you had any consultation with the new Administration on this point or on the budget in general; and, if so, are there any changes that you can tell us now that may be pertinent?

Dr. FLETCHER. I was going to answer the second part of that question in a second, but let me just comment on your comment. Remember that the Space Station is part of the R&D budget.

Mr. ROBERT C. SMITH. Right.

Dr. FLETCHER. So the biggest increase in the R&D is the Space Station. So within that line item is where it impacts on Pathfinder, CSTI, and other things of that sort, but not so much on space science.

I've been in conversation with the Bush Administration on a number of subjects, but I, I don't think it's—we have not discussed this particular budget and I don't expect that there will be many changes to the NASA budget, but there's always a surprise. We did not talk specifics.

Mr. ROBERT C. SMITH. That's—thank you, Mr. Chairman.

Mr. NELSON. Mrs. Morella?

Mrs. MORELLA. Thank you.

Dr. Fletcher, I notice on page 9 where you comment on the budget in the statement, the testimony we have before us, there is a discussion briefly of the private sector investment and involvement. And so, and I know that the 1990 budget does seek to privatize portions of the NASA program.

I'm wondering about how are you going about doing this. How is the privatization going to take place and whether industry is involved, has been involved. If you could expand on that facet.

Dr. FLETCHER. Mrs. Morella, that's an awfully good question, and I think it needs some clarification. There are different pieces of that privatization initiative in some cases that are more similar to other parts of government, like I mentioned bridges and airports and so forth, and that's our ground facilities. These are facilities that are needed for the program. Some of them actually in line facilities for the Space Program.

For those ground facilities, we think there's a good chance that we can get the private sector to sign up for those if we can come up with ways that they can make a profit on their investment, by joint use or gain something from the technology or whatever. And we think there's a good. And I've forgotten, there's something like 6 of those items.

Tommy.

Mr. **Campbell**. Four.

Dr. **Fletcher**. Four of those items.

Then there's another category of things which are at the other extreme; that is, highly technical R&D programs like the Flight Telerobotics System for the Space Station. Remember this is a big arm, very sophisticated, using artificial intelligence and all of the technology we can find to help assemble the Space Station. That is—we'll have a tough time with that.

We've already got a competition under way and there's at least two contractors bidding on it, and it's not too many weeks before we have to make a decision on that. I'll have to honestly say we haven't figured out how to make that attractive commercially. That's at the other extreme.

In between is one that we haven't quite settled on, and that's the Extended Duration Orbiter. Parts of that may lend themselves to privatization—third-party financing, if you like, but part of it impacts on the safety of the Shuttle and we can't turn over at this point to the private sector parts that may jeopardize the safety of the Shuttle. So we have to divide that into pieces.

And, also, there's a lot of problems on Extended Duration Orbiter that really haven't been worked out yet. We've talked about it for at least a year. It's a very good thing to have. Sixteen days of extra microgravity and life science work is a real advance, a great leap forward, but it isn't easy to do. And, until we've made up our mind, just how do we do it, how do we get the astronaut accustomed to those long times and still be able to land the Shuttle approximately in the place where it's supposed to land, it's a little bit uncertain. But, nevertheless, we've said we would make best efforts to try to privatize the Extended Duration Orbiter.

So those are the three categories of things. One of them highly technical, and we don't quite see how to do that yet. The middle ground is something that we know how to do, except we've got some problems with training and the astronauts, and so forth, and we haven't made up our mind what it is we want to do. Then the other category looks like a very good bet, and that's the ground facilities. And so I think we've got some things worked out which you'll be pleased with on the ground facilities, and there is a fair amount of money in those. A little over a hundred million in those ground facilities, and we need those. They're in line facilities and I just hope that Congress signs up to those.

Mrs. **Morella**. If you could have your wish with each of those three categories about what could be done, should be done, what you would like to see done, what would you envision to expedite?

Dr. **Fletcher**. Well, on the ground facilities, we're pretty far along there. I think it's a question of identifying those facilities, which I think we have done, and, by the way, we've identified one or two others. Maybe not to this Congress, but we'll give you a list of those for the record or, if you like, we can discuss them now. We're pretty far along on those and we know what we have to do there. We would just simply go out for bids and see who shows up.

Mrs. **Morella**. So that's not anything extraordinary——

Dr. **Fletcher**. Yes.

Mrs. **Morella** [continuing]. And that should go along all right——

Dr. **Fletcher**. In the case of EDO, we have to really define what we want a little better, and we're getting close to that. Mr. Myers may want to comment on that, on the 16-day version anyway. On the FTS, I'm pessimistic about whether we can actually figure out a way to use the contractors that are bidding and then convert that into a private initiative. We really haven't figured out a way to do that yet.

And, if we start over again with a brand-new competition and so forth, we won't make our schedule. So we're caught in between a rock and a hard place, I guess is the right way to say it, on that one.

Yes. Mr. Myers reminds me that we have one other privatization initiative which is left over from last year, and that's the facility for the Advanced Solid Rocket Motor, and that's a special case. We think that can be done, and we've worked that out carefully. But we have to allow both private and—we call it COCO and GOCO facilities, and the Source Selection Board decides which is best for the U.S. Government. That's what the RFP calls for, whether it's better for the country and the U.S. Government to go for a government-owned, company-operated facility, in which case we would need money for facilities, or whether it's company-owned, company-operated. Then the company would have to put up their money. That decision has not yet been made. No matter which way it's made, we know how to proceed from there. Except if it goes GOCO, there isn't enough money in the budget to do that, and we'll need some help from you if it goes that way. But right now we, the Source Selection Board is not scheduled to report out for another month or so—a couple of months, so we're not quite faced with that one yet. I'd forgotten to mention that in the list of things. That's a special case.

Mrs. **Morella**. Well, I hope you'll just, you know, keep us posted inch by inch as you progress. Thank you.

Thank you, Mr. Chairman.

Mr. **Nelson**. Dr. Fletcher, as you consider the Extended Duration Orbiter, which you would basically have support in this committee for, there has been some concern expressed by the Astronaut Office about wanting to have the automatic landing capability perfected so that, if there was any additional incapacitation for 23 days on orbit, that we would have that as a capability. What's your latest thinking there?

Dr. **Fletcher**. Well, we've spent a lot of time thinking about an automatic landing capability. I'm going to ask Mr. Myers to comment on the reason for it in a minute. But it's a straightforward thing to do, but it does take a lot of money. Estimates I've heard run around $150 million, and before we decide to—that's, a lot of that is for simulation and practice and things of that sort, not for actually implementing the capability. We really already have that capability now. Dale says almost. It's approximately there.

But the problem is we've got to practice with it and we've got to convince—and I'd want to be convinced myself—the astronauts that it's safer than a pilot landing it. No pilot is going to want to trust the automatic landing system without a lot of checkout and so forth.

Mr. **Nelson**. And you say that's a $150 million item?

Dr. **Fletcher**. That's a—roughly. That's a best guess at this point. I don't want to, us—I don't want you to hold us to that figure.

Mr. **Myers**. Mr. Chairman, we do have a study under way that's going to be completed by the end of this fiscal year on the subject of the cost and the actual implementation, including the training programs and so on, that would be required for automatic landing.

Mr. **Nelson**. Would that study be completed in time so that a decision and the funding can be provided for Orbiter 105 that is now under construction?

Dr. **Fletcher**. I'll have to turn to——

Mr. **Myers**. Yes, I think that would be so. I think we had planned to have it finished by the end of the calendar year, but I'd think that the essence of it could be completed by the end of the fiscal year. By the end of this fiscal year.

Mr. **Nelson**. And that gives you enough time, then——

Mr. **Myers**. Yes.

Mr. **Nelson** [continuing]. To integrate it into——

Mr. **Myers**. The problem that you have with the automated landing is that it goes back to the overall picture of this Extended Duration Orbiter. We have flown up to 10 days with the Shuttle. We have a plan for instrumentation, medical activity and so on, to lead to incremental increases. We expect that by the late, by late 1990 that we would, if everything goes well, we'll be up to 16-day capability. OV–102 will be modified for that capability and the—we plan to make provisions for long duration capability in 105. With all of that, we would end up with 2 vehicles that could be used for long duration activity.

The problem that you get into is the issue of our understanding, or, perhaps, lack of understanding of the readjustment to 1 g when you re-enter from 0 g. The time that it takes to get all of your neurological systems and physiological systems back in business again to take advantage of the tremendous training program that we have the astronauts use on landing.

So we are concerned about and really don't have the answer as to how fully back up to speed the astronaut is after longer and longer times in space before he lands. We don't know that it's a problem. We just want to understand it better and to be able to cover ourselves as a backup. We want to look at the additions that you'd have to make to the orbiter to give it a full automatic capability.

It has an automatic landing capability now. It doesn't have an automatic steering capability after it's on the ground. It doesn't have an automatic gear down capability, and I'm not sure we'd want that. So there are some things that are not automatic in the system today. We need to look at those and see how all that fits together in an overall program that includes the need for durations beyond 16 days and the cost of getting into a program of that nature.

Mr. **Nelson**. Mr. Skaggs, before I turn to you, let me just follow this up.

Would you hand the microphone to Mr. Abbey? And could you tell us what is the thinking in the astronaut office about 16 versus any other addition—20, 23—and their feeling about readaptation to 1 g and warning, automatic land?

Mr. **Abbey**. I don't think it's necessarily an automatic landing problem. The problem is really a readapting—as Dale has said, readapting to a 1 g environment, and that takes a period of time. We started out earlier in the program with auto-land. We experienced some difficulty when we introduced the pilot into the control loop at a low altitude. Auto-land in itself will not solve the problem. He'd till have to be able to take over for auto-land and he has to be able to come into the control loop in case the Auto-land system isn't working.

For the problem related to 16 days or 28 days, it is one where we have to understand how we might condition the crew to better adapt to the 1 g environment and alleviate that problem. So Auto-land is a part of it. Auto-land would be a consideration, but it would take a good expenditure of money to get the auto-land system certified as a primary control mode before we could really fly with it.

Mr. **Nelson**. Is there anything that we can learn from the Soviet program in their long duration flight that would be beneficial to us understanding about just how much the commander and the pilot would be affected?

Mr. **Abbey**. Well, I think it's not a problem related to how long he can stay on orbit. It's a problem related to the effect of staying on orbit and your body adjust to making control inputs and flight inputs and you get your whole mind and your whole logic system conditioned to that. Then when you come back into the atmosphere and you have to make a landing, you have to go through some period of adjustment where your input into the control loop becomes adjusted. For that reason we have put the pilot into the control loop at 40,000 feet, so he has an opportunity to readjust by the time he gets down and has to accomplish the landing.

Mr. **Nelson**. I see. So your concern is if you had a failure of the automatic land somewhere in the process and he had to immediately respond——

Mr. **Abbey**. That's correct.

Mr. **Nelson** [continuing]. Manually.

Mr. **Abbey**. That's right.

Mr. **Nelson**. Whereas, under the present system, coming in from 40,000 feet even with extended duration of 16 or 28 days, you feel like that he would have enough adjustment regardless of that extended duration?

Mr. **Abbey**. Yes. The program that we're embarking on, to go to 16 days and then look at going beyond that, is one where we're trying to understand how we could provide some type of conditioning in flight to expedite that as he comes back into the atmosphere. And I think we're going to start off with that and build up—building up the duration of the flights from 10 to 13 and then to 16, and I think with the medical data that we'll accumulate and that understanding I think we'll be in a position to accomplish the task manually with the automatic system as a backup.

Mr. **Nelson**. Thank you for that information.

Mr. Skaggs.

Mr. SKAGGS. Thank you, Mr. Chairman. Thank you, Dr. Fletcher, for being here.

We had pretty good luck last year on the current fiscal year budget. We're asking, and I think this committee will be strongly supportive, for a repeat of good fortune, I think. And more importantly, by getting on a track that's going to depend upon that kind of healthy increase into the future, it becomes more and more critical to have recaptured the American public's imagination about your program.

The President's going to be up here to talk to us a week from tonight. What do you hope he will say that will be the vision statement for the Space Program?

Dr. FLETCHER. Well, that's a good question. It begs—I'd hate to put words into my boss' mouth. I'm hopeful that he will strongly support, in that message, a continuation of the program that we're on and support the increase that the previous President has asked for. I think there are some global problems facing the Congress and the country right now which involve huge deficits and so forth, and I hope that in the process of describing those global problems that space will take its proper place in the describing of that problem. But more than that I am afraid I would hesitate to guess. I am reasonably sure that he will support something close to the increase that we've talked about.

Mr. SKAGGS. I didn't mean to ask you to indulge in the presumption of that part of his text. Let me put it differently.

If you were in front of a gifted high school class right now trying to encourage some of our best young people to go into engineering and the other disciplines that will be critical in the long run to the health of the Space Program, what would you tell them to capture their imagination about what we're about in this?

Dr. FLETCHER. That's a different kind of question entirely. I would—I do that often and I have a lot of fun. Believe it or not, the——

Mr. SKAGGS. I think they're the same question because if we're going to get the budget we need—but go ahead.

Dr. FLETCHER. The youngsters all understand a lot more about technology than their parents do. I guess that's a given. I used to say my children, but I have to say my grandchildren know how to work computers better than I do. They always beat me at those computer games. They know the right buttons to push. They know more about space, believe it or not, on some aspects of space, than I do, and I'm supposed to be the expert.

And I think what you do is tell them what the future is like because they're the ones that are going to have to handle the future. They need to get educated in science and technology. It's a terrible situation that we have in our primary schools. I just read a report the other day that the Koreans and so forth test higher than we do, and we're the lowest of all those countries that were tested. I think you tell them about the future. That this country is going to send people, men and women, out into space to explore space, to ultimately inhabit it—and ultimately means in the mid-1990s because we're going to be inhabiting it in the Space Station Freedom.

But, ultimately, we're going to send a base and inhabit it on the moon, but it probably won't be a comfortable base. It will have to be enclosed. It will be actually doing industry, mining the materials on there for other space programs or perhaps even bringing them back into near-earth orbit for other purposes.

We'll also be sending people to the Planet Mars, which is our nearest comfortable planetary neighbor. Venus is a terrible place to live. It's hot and it's atmosphere is sulfuric acid. I wouldn't want to live there. But Mars is nice place. It's a little cold. Got an atmosphere about like the earth had a while back.

I would talk about that and say, "You're going to be involved in that, some of you youngsters. And we're going to make it possible for you to do that." It's easier to talk to children because it's their future we're talking about. It's harder to talk to older folks because they'll be gone when all this is going on, a lot of them. I hope I'm still here, but you never know.

I think the Space Program is probably the best example this country has of its way of facing the future. I can't think of another program that's more future oriented than our National Civil Space Program. I may be wrong, but I think we look farther ahead than almost any other government agency. And for that reason, the young people are the right people to address.

Mr. SKAGGS. Well, hopefully, we're all children in the best sense and we'll be responsive to those kinds of appeals regardless of age.

Getting down to at least one concrete situation regarding a station, does your plan now envision the need for a heavy lift vehicle in order to complete station construction?

Dr. FLETCHER. Right at the present time we will be able to, Mr. Skaggs, assemble the Space Station using the existing shuttle, except for the Columbia. The Columbia is a little short of weight-lifting capacity, but the other three orbiters we can use and properly assemble the Space Station.

It would be nice if we had the extra capability. I think it's about 15,000 pounds or thereabouts from the Advanced Solid Rocket Motor. Gives us a little edge over what we have. With that margin, we would have a comfortable way of assembling the Space Station.

Now, there's been a lot of proposals about why don't we use a large lifting vehicle, something like the Energig that the Soviets have. And we have that capability also. We call it the Shuttle C. If we took the orbiter off the stack and just used the external tank and the two solid rocket motors, we could lift 120,000 pounds or so, so there could be bigger chunks of the Space Station put into place and it could be a lot simpler to assemble.

We don't plan to do it that way. We plan to use what we've got. It's always a risk if you depend on some other new program. And so right now the quick answer to your question is we can, and probably will, assemble it with the shuttle that we now have.

Mr. SKAGGS. And remind me what that implies as far as the dedication of shuttle payloads during the critical time period exclusively to station construction?

Dr. FLETCHER. Well, I'm going to turn to Mr. Myers in a moment to give the number of flights per year, but it will use a substantial fraction of our 12 or 16 flights per year that we plan, but we'll have ample number of flights left over.

Dale, do you want to give what our current estimate is?

Mr. **Myers**. Our present plans show that we'll be using 8 flights per year for the assembly of the Space Station, and then on the order of 5 per year for the resupply after that. This will be, though, in the same time period when we should have formally established and have in place our good mix fleet that we're working towards, and I think by that time we'll be in the position to have enough commercial launch vehicles in place in the system to be able to use for many of our payloads and be able to balance off that situation across that time period.

Mr. **Skaggs**. I don't want to take any more time, Mr. Chairman. I still remain skeptical about how realistic this schedule is for that kind of dedicated use of the shuttle for contruction and hope we will [inaudible] explore this further in the station hearing.

Mr. **Myers**. It is the time period where we would be at about 13 or 14 flights per year for the shuttle, so it would be roughly half of the capability.

Mr. **Skaggs**. Thank you, Mr. Chairman.

Mr. **Nelson**. Thank you, Mr. Skaggs.

Mr. Buechner.

Mr. **Buechner**. Mr. Chairman, I've got a little opening statement that I'd like to have unanimous consent to insert in the record.

Mr. **Nelson**. Without objection.

[The prepared opening statement of Mr. Buechner follows:]

STATEMENT OF HONORABLE JACK BUECHNER

February 2, 1989

Thank you Mr. Chairman - I have some brief comments I would like to make.

I want to thank the Administrator for coming before us today and to commend him on the outstanding leadership he has shown as the head of NASA. He has helped lead our space agency out of the despair of one of the worse tragedies this nation has ever encountered, one that was revisited each time the video tape played before a stunned America. He has been a partner to a rekindling of the new spirit and sense of determination that had escaped our space program. Few individuals could have taken on or much less wanted Jim's duties following the Challenger disaster. But the fact that the Shuttle is flying and flying safely is a tribute to Jim and to the thousands of men and women who helped make it possible.

It is only appropriate that as President Bush considers candidates to fill this very important position, we -- as a Committee -- call upon the President to choose someone who will continue and hopefully, even exceed, the leadership and vision that Jim has given us.

This Committee will tackle some very serious problems during the 101st Congress. To help us resolve these issues it will require, on the NASA side, a dynamic individual who can lead America's space program -- not just on the pad and before Congress -- but also in the classrooms, boardrooms and TV studios around this nation -- and yes, the world.

While the success of our most cherished programs are dependent upon the annual budget battles, it is equally important that the debate move beyond the Washington beltway and to the small towns and cities across this nation. It is public support which will sustain our space program when others are calling for reductions or its elimination. And while all of us in this room will do everything possible to see our space program move forward, it will be the primary responsibility of the next Administrator to translate the hopes and dreams of a nation into reality.

Despite the headlines, America's space program -- which includes space science -- is still number one. The problem for the next Administrator is to ensure that while we remain number one the dreams become reality. That won't be easy and yes, the Russians have made great progress. But in a commercial world, real competitors either are or will be Japan, China, and the European Space Agency.

Vital questions regarding the nature of our space program remain unanswered. Whether this nation commits to the colonization of the moon, a mission to Mars or the much heralded voyage to the planet Earth, these next few years will determine the direction of our space policy for the next half century. To meet this challenge, President Bush must choose someone who is not just competent, not just charismatic but one who has the chutzpah to deal with Congress and OMB. Most of all, the next Administrator must have the support of and access to President George Bush.

As Jim Fletcher prepares to turn the controls over to his successor, we call upon President Bush - in a gentle and kind way - to choose an individual who can take the challenge to the American people, much like the way President Kennedy challenged our nation following the launch of Sputnik.

Thanks again to Dr. Fletcher and to you Mr. Chairman.

Mr. **Buechner**. It's kind of laudatory, Doctor. It talks about how nice it was for you to come back and literally help us get out of the morass that this Nation had kind of enveloped itself in as a result of the *Challenger* disaster, and it's—obviously, the horror that we shared was revisited each time the videotape was played.

And I guess I want to play on something that Congressman Skaggs mentioned, and that is, you know, what is it we're going to do to move the Space Program forward. And I think it's fair to say that you're probably a short-timer. I think you've probably worked a little deal out with the President, and I think—I'm glad you're on board. I'm glad you didn't sail off into the sunset. But I think we have to look at what goes on beyond.

And, as the President comes to this body and talks to us about the things that he wants, and we talk back about the things that we want, it appears to me that the issue of space—and I've said this to people in the industry and out, you know, what is it that's going to make sure that the Space Program as has been requested moves forward? I think it requires a great amount of definition, and I think we'd all agree that NASA has not had as much definition as this body probably wanted and even in turn we wanted. And so I'm just going to use some of my time to say that the person that succeeds Dr. James Fletcher I hope is a person that's, as you have done, is prepared to go into the classrooms of America and the boardrooms of America and into the TV studios. We live in an age of communication, and the next person is not only going to have to be competent, they're also going to have to be charismatic—not to say that you're not—and also have a little chutzpah.

Dr. **Fletcher**. I've already admitted that, Mr. Buechner. [Laughter.]

Mr. **Buechner**. Have a little chutzpah and go out and be a salesperson. I know as—there was two of us in the Budget Committee that spent a lot of time working on the 250 function last time, and one of them has gone and I've been looking for an ally. And if you've got one, send him over.

But, I guess what I'm trying to say is, and I hope you appreciate it and maybe can—and push the President this way, that I really believe that when JFK said, you know, took the issue of space to the American public and made it a national commitment the public responded. And when we finally got back into space, I think the public was kind of back in the mood to move forward. And I'm tired of people beating up on the United States as being a second-rate power, and I'm tired of the yen being predominate over and above the spirit that this country has, and I believe that space is where we are still number one, but I look out at our competitors—and they're not just the Soviets, they're the Chinese, they're the Japanese, they're the Europeans. I mean, this is something that we're there and we have to keep going.

And I would hope that you would communicate to the President that—and to Congress, that it is imperative that the next Director takes all of your traits and builds on those and uses the bully pulpit and gets out there and gets the American people kicked in the butt to where they believe in space and believe in this country and stop listening to, you now, the nay-sayers.

Dr. **Fletcher**. Mr. Buechner, I, first of all, I want to thank you for all of your efforts last year. We would have been in a bad way if you hadn't used all your talents in the House.

With regard to the other comment, I think you're absolutely right. I think we've put a team together that's put NASA back on the right track as far as the fixing of the shuttle and the setting of the goals and programs that we need for the future. I think we do need—the next Administrator ought to have a little, I think you used the term chutzpah, and I think that's the kind—because I've done all the work. Let him do the selling. [Laughter.]

Believe it or not, I have talked to the President about that.

Mr. **Buechner**. On a little more mundane issue, I'm a little concerned about CDSF. I really would like to know, does NASA plan to underwrite that program regardless of what the studies report?

Dr. **Fletcher**. Well, of course, you're prejudging the results of the study, Mr. Buechner. I think we're on a track which I think is a reasonable track after a lot of dialogue back and forth with this committee and others to decide (a) whether we need a CDSF, and that depends on what the industry and science requirements are, and (b) if we need it, what should it be? And I apologize. We should have done that before we came to you last year but we didn't have time. We are now on that track and we're going to sign up, and based on the advice of the various groups that are working on the program, the industry group that's going to submit responses to the RFI, the National Academy of Science that's making a study of the science and commercial requirements, and also the National Academy of Public Administration that are looking at the configuration and what kind of investment is required to build it, and the cost.

Mr. **Nagle**. Will the gentleman yield?

Mr. **Buechner**. Certainly.

Mr. **Nagle**. I'm curious in light of your statement that perhaps, as many of us felt, Dr. Fletcher, that you—that some kind of pushed the CDSF on us, why NASA prior to the completion of the studies that you've just described, that we're waiting for to make a decision, went ahead and took the step of issuing RFPs?

Dr. **Fletcher**. We did not, Mr. Nagle, issue an RFP. We issued an RFI.

Mr. **Nagle**. Thank you. What's an RFI?

Dr. **Fletcher**. That's a Request for Information. This will help us decide what kind of a program we ought to have in the CDSF. We thought that would really supplement what you have asked us to do on the National Academy studies.

Mr. **Nagle**. There was a—if I understand the congressional action last year, and I'm just pulling this from the recess of my memory, but if I understand the congressional action last year, you were to do nothing until there was an NRC—National Research Council—report. Did I miss something?

Dr. **Fletcher**. Well, we—when you say nothing, we—Mr. Nagle, I was hoping you would give us an easier time this year since this is my last couple of months or so. [Laughter.]

Dr. **Fletcher**. But——

Mr. **Nagle**. Welcome back. [Laughter.]

Dr. **Fletcher**. Well, we don't just sit on our hands.

Mr. NAGLE. We decided a long time ago this is not personal. I mean, you know, this is——

Dr. FLETCHER. I understand. We thought, we want to gather as much information as we can about what should the CDSF be if we have it, and the RFI it seemed to us was a good idea in terms of getting industry inputs on what a CDSF might be, and that, I hope, was in the spirit of your direction last year.

Mr. NAGLE. Can I ask—if the gentleman would yield further, can I ask one other question? I also was, and I don't want to spend the rest of the year on the CDSF as I spent last year, but I'm curious, Dr. Fletcher, as to why the acknowledgment is now that we should have been submitted more information on the CDSF or we should have had further studies on the CDSF as your statement this year as to the agency's strong advocacy for it last year in the face of congressional restraint. I mean, how do we avoid going down that road again, which both you and I would like to do?

Dr. FLETCHER. Well, as you know, last year we signed up to a Presidential directive that came out in February, and then I think we addressed this committee within a month or so after that, and we didn't entirely have our act together. What we did say, I think—I hope we said, was that it looked as though the CDSF could be used for useful things. That NASA and the rest of the Government had $700 million worth of reason to go ahead with it. We——

Mr. NAGLE. But that's history. How do we avoid that in the future—I mean, the kind of box we got into last year, is really my question?

Dr. FLETCHER. I'm hoping we don't get into that box. I'm hoping that we have now a better substantiated reason for something like the CDSF with the studies going on at the National Academy. We hadn't done that carefully last year. You, properly, asked us to do it carefully this year and we are.

We hadn't really—we really didn't have a good idea of how much it was going to cost and whether this 700 million was really 700 million or some other number. Because it had already jumped up from something like 300 million to 700 million in the time we were discussing it with them, and we hoped to be able to come up with a right configuration that will do what we want to do rather than what some one contractor wants to do. If we put that all together, together with the information we'll get from the RFI, I think we'll have the data that you would want to justify either going ahead or not going ahead with CDSF.

Mr. NAGLE. I think the—I think Dr. Fletcher for his answers. I thank the gentleman for yielding.

Mr. BUECHNER. I thank the chairman for giving me so much time. [Laughter.]

Mr. NELSON. The time of the gentleman has expired.

Mr. NAGLE. The chairman is very generous. He's a very generous man.

Mr. BUECHNER. Doctor, I just want to reiterate the comments I made earlier. I thank you very much for your tours of duty. You've been a very capable and able Administrator, and I'm going to hate to see you go, but you've been very, very good with this committee. I know we've always—you've gotten beaten up upon in this room occasionally, and I think you've survived quite well. And good luck to you.

Dr. FLETCHER. Thank you, sir.

Mr. SKAGGS [presiding]. The gentleman from New Mexico, a new member of the subcommittee, Mr. Schiff.

Mr. SCHIFF. Thank you, Mr. Chairman.

Dr. Fletcher, I'd like to introduce myself to you and to the staff. My name is Steven Schiff. I've just joined the subcommittee, the committee, and the Congress all at once here this month.

I wanted to ask about one thing, if I may, on the Space Station. I see that the budget request includes approximately $2 billion for continuation of the research into the Space Station. I just want to clarify for my own mind. The Soviet Union has a space station now, is that correct?

Dr. FLETCHER. That's correct, Mr. Schiff.

Mr. SCHIFF. All right. Is the Space Station we have in mind, is it more or less identical to what they have in mind or is it more sophisticated or less sophisticated, if I may ask that question?

Dr. FLETCHER. The difference, Mr. Schiff, between the Soviet space station and our own is really night and day. They have a very limited capability, although they do have the capability for testing people, human beings for long duration in flight, and that's the major purpose of their machine. But, whereas their machine probably weighs, the M-I-R—the MIR probably weighs in the order of 40,000 or 50,000 pounds, our Space Station will probably be of the order of 550,000 pounds. It's a huge device and can do a lot more things. It can do microgravity; it can do astrophysics, looking up; earth observation, looking down; it can do not only life science, human physiology and so forth, but can accommodate a centrifuge which will allow artificial gravity to be applied. It really is an entirely different kind of a space station.

Having said that, however, their MIR is now, and ours is not till 1995. It's quite possible that by 1995 they will have put up a space station comparable to ours. Our hope is that the sophistication of the scientific experiments and the other kinds of activities that we do in our Space Station will still be more advanced than theirs. We have no guarantee of that.

Mr. SCHIFF. Dr. Fletcher, thank you. I asked you about some of the things about our Space Station because I've already been asked, and I'm sure the more senior Members of Congress have been asked much more than I, about the cost of the Space Station and what we will get out of it in view of the budget deficit that you've heard about and we've heard about, and I appreciate you telling me a little bit about it. Thank you.

Thank you, Mr. Chairman.

Mr. SKAGGS. Mr. Rohrabacher.

Mr. ROHRABACHER. Dr. Fletcher, we're in a time of a high level of deficit spending, everybody's concerned about a buck, and perhaps you could—to my way of thinking, one of the answers is to try to get private investment in some of our space operations. Perhaps you could tell me some of the things that you believe that we could be doing in the future that would attract private investment in some of our space efforts that we aren't now doing.

Dr. **Fletcher**. Mr. Rohrabacher, we're not experts in this but we're learning rapidly. We've done a lot of things to get the private sector involved, the earliest, of course, being the communications satellite industry. We founded a whole new industry early on. We've made other attempts. The Tracking Data Relay Satellite started out to be a private investment, but that's not one that flew very well. And we, you take—you try experiments and take a risk, some times they don't always work out.

But then we tried another private sector investment, and that is the upper stages for the shuttle, the ones that bunch payloads to synchronous orbit, geosynchronous orbit, and we've been very fortunate there. We have a number of contractors actually supplying that upper stage. One is the Mobil Science Corporation, which makes the TOS upper stage; McDonnell Douglas makes stages for the, originally for communications satellites called the PAM-D; and now, this year, we have—I've lost track—something like 7 initiatives worth $200 and some odd million dollars to begin to do that.

And we're learning. I think as time goes on we'll be able to get a larger private investment, but I think $200 million is a sizable private sector investment these days. And we've got some plans for doing other things. I don't know whether—yes, I guess it's all right.

When I was in the private sector we tried to buy a shuttle and then rent it back to NASA, but the accident changed all that. We had need of an orbiter much earlier. But that's a—those larger investments are also possible, and I think gradually we'll move the private sector more and more into the——

Mr. **Rohrabacher**. When you mentioned a sixth orbiter, what's the possibility of having a private company finance that?

Dr. **Fletcher**. I'm going to get in trouble with my boss if I start talking about that sixth orbiter very much more, because that has not been approved. I talked about it because I sincerely believe we need another orbiter, but I really shouldn't be speculating on how we're going to finance it at this early stage. We won't be able to even start it until late 1991, so I guess it's premature to do that.

Trying to anticipate your concern, though, I think that's one sector we ought to look at to see whether that can be done.

Mr. **Rohrabacher**. Well, what do you foresee? You see 20 years from now that possibly we could have private companies manufacturing and owning vehicles like this, and that we could be relying more and more on private companies rather than NASA for some of these activities?

Dr. **Fletcher**. Sure. Absolutely. We've already done that for the Expendable Launch Vehicle industry, and I think rather well, as a matter of fact. We started doing it right after the shuttle accident, the *Challenger* accident, and I think the Expendable Launch Vehicle industry is in reasonably good shape. We had some help from this body. There were a lot of problems that had to be worked out.

Mr. **Rohrabacher**. In terms of the amount of money that's going into space exploration and utilization, how much is coming from the private sector as a percentage of what's coming from the Government sector at this point?

Dr. **Fletcher**. Well, we have to differentiate between investment by the private sector and performance. Ninety percent of what

NASA does is done by the private sector. We don't do very much of our own building and developing.

Mr. Rohrabacher. Right.

Dr. Fletcher. And the investment from the private sector, I'd only—it would be a wild guess if I gave it to you. I can mention the programs, but I don't really know how much was invented in those programs—invested in those programs. We're asking this year for another $200 million or thereabouts just for this fiscal year from the private sector. I'm not sure that counts the ASRM. The ASRM is more like another, an additional six—$600 million?

Mr. Campbell. Sixty million.

Dr. Fletcher. Sixty million for this year, but the total we're asking for from the private sector is——

Mr. Campbell. Two to three hundred million.

Dr. Fletcher [continuing]. $300 million; yes. We're asking for $200 million from the private sector for these smaller investments plus, if the Advanced Solid Rocket Motor goes, another $300 million from them. That's a fairly sizable start.

Mr. Skaggs. I neglected to say welcome to the gentleman from California, who is also a new member of the subcommittee.

Mr. Tanner, I understand you have no questions. But likewise, we're glad to have you here.

And, Mr. Smith, any questions?

Mr. Robert Smith of New Hampshire. No questions. Thank you.

Mr. Nelson. Mr. Nagle?

Mr. Nagle. Doctor, I just have a few. It will probably come as a shock to you, Dr. Fletcher. [Laughter.]

Let me say at the outset that, although I've only been here 2 years, I've enjoyed the relationship, and I, like many on the committee have already said today, I'm not unmindful of your contributions to the program both in this tenure and your prior tenure. Nevertheless, I still have some reservations, perhaps, about some of the direction that are, frankly, honest differences of policy and not necessarily any reflection on your intelligence or capability.

You've requested that the committee, and I think I can quote from your testimony—"It is extremely important for Congress to act quickly to approve necessary legislation in support of private sector investment in these critical areas," and you outline in your testimony a series of positions that you thought we should go ahead and authorize, and in addition to that we should engage in a process of termination of liability, I think is the technical term for it.

Could you just list for me—because they're kind of scattered through your testimony, could you just list for me the areas that you feel Congress should engage in that "termination of liability," which specific projects that you are requesting at this time that we do that?

Dr. Fletcher. Yes, Mr. Nagle. I'm going to ask Tommy Campbell to provide that list in a moment.

The reason for the urgency is that some of those items are in line in terms of the Space Station and the Advanced Solid Rocket Motor and other really crucial programs which are multi-billion-dollar programs that we would slip the schedule if we don't get termination liability early. That's the reason for the, I don't want to haste, but the quick reaction.

Tommy, do you have a list of those that——

Mr. NAGLE. Could you just—before Tommy starts with the list, could you tell us specifically your definition of "termination liability," just in case there's somebody here who doesn't know what we're talking about?

Dr. FLETCHER. Oh, I'm sorry. Yes. Good point, Mr. Nagle.

The problem is, if we expect a contractor to invest a sizable sum money—and, typically, we're talking anywhere from $10 or $15 million up to $300 million—they want to have some guarantee that if we change our mind on this facility and we decide we don't want this facility that we compensate them for what they've already invested. And so termination liability is a guarantee that they will be compensated for the work that they have performed up until the date of that termination. I think that's the best I can do. I'm not a lawyer, but, in nonlegal terms, that's what termination liability is.

Mr. NAGLE. I think that's satisfactory.

Tommy? Or, Mr. Campbell, which projects?

Mr. CAMPBELL. Yes, Representative Nagle. What we would really request this year, we think we need, sir, is generic termination liability for the facility projects. We need an early decision on the ASRM before the selection is made, and that selection is scheduled currently for the April time frame.

For the other facilities, I can list the ones involved in this year's budget, sir, but our, our desires——

Mr. NAGLE. If they're limited to this year's budget, then fine. But you're asking, I understand——

Mr. CAMPBELL. No, we're asking for generic. That's why I say general——

Mr. NAGLE. Yes.

Mr. CAMPBELL [continuing]. Termination liability for facility projects where private financing is involved.

Mr. NAGLE. Which ones?

Mr. CAMPBELL. The Neutral Buoyancy Lab.

Mr. NAGLE. Go ahead.

Mr. CAMPBELL. The Space Station Processing Facility at Kennedy and the Observational Instrument Lab at Jet Propulsion Laboratory. And, as I mentioned earlier, we would desire the Advanced Solid Rocket Motor language to be enacted earlier than the '90 authorization bill.

Mr. NAGLE. How about the Flight Telerobotic Service, sir? You requesting it for that?

Dr. FLETCHER. Yes, we are requesting for that, but I'm not sure we have our act together on that, Mr. Nagle. That's a tough one to do because we've got contractors already competing on the basis of the old system, and we'll have to come to you with a special request on that, if and when we decide how we're going to do it.

Mr. NAGLE. Well, could we modify your request, then, for generic termination liability to exclude the Flight Telerobotic Servicer, that would be acceptable?

Dr. FLETCHER. I think so.

Mr. CAMPBELL. The language we had worked on for this year's authorization is restricted to facilities.

Dr. **Fletcher**. The ground facilities.

Mr. **Nagle**. Okay. And the solar dynamic power, you wouldn't request generic termination liability for that one?

Mr. **Campbell**. Well, let me turn to the lawyer.

Dr. **Fletcher**. This is Mr. Gary Tesch.

Mr. **Nagle**. Sure.

Dr. **Fletcher**. I'm sorry. Ed Frankle had to leave, and Gary is the Deputy General Counsel, Mr. Nagle.

Mr. **Nagle**. Well, fine. I just want to know how far we're supposed to go here.

Mr. **Tesch**. It's part of being a deputy, I guess.

Mr. **Nagle**. Pardon?

Mr. **Tesch**. I said it's part of being a deputy. Mr. Frankle's gone today.

Basically, it depends on how you want to phrase your question. We would want—we would need termination liability in any of those instances where the costs were in excess of the available appropriations. That's the main thing.

Mr. **Nagle**. So you would basically say that you would like the generic language to include, then, not in contradiction but in further expansion of Mr. Campbell's answer, the Flight Telerobotic Servicer, the solar dynamic power, and the docking module?

Mr. **Tesch**. If those programs were privately funded, I would think so; yes, sir.

Mr. **Nagle**. Well——

Mr. **Tesch**. And presently, in the bill is just the facilities. You know, section 8.

Mr. **Nagle**. Tell me which projects those are on the facility, will you please?

Mr. **Tesch**. That is a generic authority in the bill, in section 8, for the facilities.

Dr. **Fletcher**. Let's list the facilities again, Tommy.

Mr. **Nagle**. List them again.

Mr. **Campbell**. It's the Neutral Buoyancy Laboratory at Johnson, the Space Station Processing Facility at Kennedy, and the Observational Instrument Lab at Jet Propulsion Lab.

Mr. **Nagle**. Now, of those 3, how many of those have you done preliminary studies on to see whether or not there would be, even in the feasibility theory, a commercial interest?

Dr. **Fletcher**. I think we've done studies on all of them, Mr. Nagle, in varying amounts. I think we're ready to go as soon as we get that termination liability.

Mr. **Campbell**. We have solicited interest already for the Neutral Buoyancy Lab.

Mr. **Nagle**. Yes.

Mr. **Campbell**. And the Space Station Processing Facility at Kennedy.

Mr. **Nagle**. Yes.

Mr. **Campbell**. And we have some responses in the order of 30 and 50 indications of interest. We have to proceed——

Mr. **Nagle**. Have those been a godsend at all?

Mr. **Campbell**. No. We have to proceed beyond that. What we were in—what we had planned is——

Mr. **Nagle**. To avoid the problem we had with the CDSF that we talked about earlier today, shouldn't we do our studies first to see which ones are feasible before we grant termination liability authority on all of them, including the non-ground facility categories?

Dr. **Fletcher**. Mr. Myers is going to answer your question. But one of the problems we got into is when we—and, by the way, we were asked by OMB to look at these specific projects, and we had some of our own. But they're in line, and so we're going to justify them the best we can. But they're necessary facilities, they're well-defined facilities. We won't know what the extent of the industry participation is until we actually send out for bids.

Mr. **Nagle**. Why don't we do that first and then find out where we need termination liability, rather than a generic response?

Mr. **Campbell**. Well, actually, our approach was to consult with the Congress and to get a response from the Congress before we proceeded on the RFPs for the——

Mr. **Nagle**. What I'm trying to get at is two concerns. The first is we don't get ourselves into the CDSF, which I understand your own agency had deep reservation about, and your own studies inside your agency had shown that perhaps were not as meritorious as what the Economic Policy Council decided that they were.

What I'm saying is why don't we do our studies before you ask for the generic authority?

Dr. **Fletcher**. Well, Mr. Nagle, I think there's an entirely different situation we're talking about here. These are ground facilities, well defined. We know we need them. There is no uncertainty about any of that.

Mr. **Nagle**. And studies have been done on all of them?

Dr. **Fletcher**. On all of them, yes. Very careful studies. In fact, some of them have been over a 2-year period, so the facility is well defined.

Mr. **Nagle**. All right, then let's give those out and then let's talk about the Flight Telerobotic Servicer, the solar dynamic power and the docking module.

Dr. **Fletcher**. There I think you have a point, Mr. Nagle. Those are more in the category of what we were talking about last year, except for the following difference. The FTS is something we know we need, and we do have a problem there and we're not asking for generic termination liability for that.

Another one is this Extended Duration Orbiter. We are very close to being able to request termination liability there, but we haven't asked for it in the generic term. The things that we're asking for generic termination liability are the ground facilities, which are very well defined. They are not R&D projects. They are buildings primarily, and I hate to use the word "swimming pool," but they're neutral buoyancy tanks, I think we call them.

Mr. **Nagle**. I know what that is.

Dr. **Fletcher**. Those I think are well defined, and so we're not talking about whether we need something or not in those cases. We're talking about what's the best way to get industry to sign up for private financing.

Mr. **Nagle**. One more question on this line and then move on. You would be comfortable, then, in saying that the result of your investigations there is a capacity of private sector investment in the 3 ground facility projects that you've recommended that we give termination liability on?

Dr. FLETCHER. That's correct, Mr. Nagle.

Mr. NAGLE. And you'd be uncomfortable because of a lack of study asking us to give generic termination liability insurance to the non-ground-facility projects that you haven't enumerated here, because you haven't had studies?

Dr. FLETCHER. I would say instead of uncomfortable, less comfortable, and we owe you some more information on those, Mr. Nagle.

Mr. NAGLE. All right. Okay.

Now, if I could turn to one other question.

Dr. FLETCHER. Before we leave, the ASRM is another category entirely, and that we also have well defined and we need termination liability for that. Not generic, this is a special case. We asked for it last year, didn't get it. But we need it before we can make the source selection on the ASRM, and so that's a different kind of a problem again.

Mr. NAGLE. Let me pursue just an offshoot of what we just talked about, though. If we give you generic termination liability on the 3 ground facilities that you've requested, are those 3 essential to the development of the Space Station?

Dr. FLETCHER. Well, 2 of the 3 are: the neutral buoyancy tank and the facility at the Cape.

Mr. NAGLE. Space Station Processing Facility?

Dr. FLETCHER. Space Station Processing Facility.

Mr. NAGLE. Would that, then, be reflected in any budget submitted to us by the Administration as being "off budget"?

Dr. FLETCHER. Well, I think the term "off budget" can be applied loosely. We think there's a fair chance that we can have multiple use of those facilities, and in that sense it's not precisely off-budget financing but it's really cooperation with industry to get the best buy for the Government.

Mr. NAGLE. Um-hum. And what about the 3 that we've mentioned, or the 4, I guess—the flight, the solar, and the docking module and EDO—are those in the budget for the Space Station or was it anticipated that if we give generic liability for a study that hadn't been done yet that those won't be on the budget for the Space Station?

Dr. FLETCHER. Your question is quite appropriate on those facilities. We need, we're not asking for generic termination liability insurance at this point. We're asking you to consider termination liability, but we owe you some more information before we could expect to get that.

Mr. NAGLE. How does that impact on——

Dr. FLETCHER. Now I want to make sure again that I—the ASRM is in a different category. We asked for that last year.

Mr. NAGLE. I'll come to that.

Dr. FLETCHER. And we didn't get it.

Mr. NAGLE. I'll come to that.

How do we know—I remember a terrible hearing for all of us, I think, including Mr. Myers, that we went through with Mr. Perkins on what the cost of the Space Station was. You know, was it 15 billion in 1981 dollars? Was it 20 billion in 1985 dollars? I never did understand what you were—anybody was saying there, but I remember Mr. Myers was there. But how does this distinguishment that we're drawing between those we're giving generic liability to and those that we might give generic liability to impact on the cost of the Space Station itself? Or do we know yet?

Dr. FLETCHER. I think we can make an estimate of that, but basically what happens, Mr. Nagle, is if we don't get the neutral buoyancy tank, which is something——

Mr. NAGLE. No; we're not on those. Those are off the—those are off——

Dr. FLETCHER. Oh. If we don't get the FTS——

Mr. NAGLE. No. No. No. No. No. No. Set those aside. I'm just talking about the NBL, the solar, the robotic arm, et cetera.

Dr. FLETCHER. Each one of those in a different category. In the case of the Flight Telerobotic Arm, it would simply delay the date on which we would get that instrument. In the case of the solar dynamics, I'm not sure that would impact in any major way the——

Mr. NAGLE. Docking module?

Dr. FLETCHER [continuing]. Space Station. The docking module, I don't think we're asking for termination liability this year.

Mr. CAMPBELL. No. I think the question is what impact is the adjustment on the cost.

Dr. FLETCHER. Yes. Our projected cost——

Mr. CAMPBELL. It would reduce the cost in the near term——

Mr. NAGLE. If——

Mr. CAMPBELL [continuing]. Depending upon the arrangement, whether you had a share arrangement, you know, a multi-use of the system. Then it could reduce the total cost.

Mr. NAGLE. Yes. And I appreciate the indulgence of the chair, but let me pursue this.

When we get a budget submission for this year, as I'm sure you will, for the Space Station, will it include the alternatives on those 4 non-ground-facility items that we've talked about, both if they're privately developed or if we have to do them ourself? In other words, will we get an alternative budget this time so that we know if we're going to walk—I don't know what the cost of a telerobotic arm is, but if we have to walk into the cost of a telerobotic arm ourself with more money up front, will the agency submit us at least the alternative figures?

Mr. CAMPBELL. We have provided them to the staff, I believe, Congressman Nagle. They are available because they are—there is a run-out implication of the 200 million in the order of 700 million.

Mr. NAGLE. Okay.

Mr. CAMPBELL. And those have been analyzed and presented.

Mr. NAGLE. I think the last question on this thing. When can we anticipate the results of any studies or inquiries that NASA has done on these 4 non-ground-facility projects as to the feasibility of turning those over to the commercial sector?

Dr. FLETCHER. Well, each of them in a different category. In the case of the Extended Duration Orbiter, Mr. Myers, in another month or so we ought to have a pretty good justification for that. We've got to work out some of these problems with the fatigue of the astronauts and so forth.

In the case of the Flight Telerobotic System, I wish I could give you a date when that's settled. That's the toughest one of all and I'd be a little reluctant to give you a date there. But I would hope in the next month or so also, but that's a very iffy program.

In the case of the solar dynamics facility, I don't see why we can't do that right away.

Mr. **Nagle**. Because studies have been done?

Dr. **Fletcher**. Dale?

Mr. **Myers**. We haven't dealt with that one yet.

Mr. **Nagle**. Why don't you do it in writing? Why don't you just tell us in writing a time frame?

Dr. **Fletcher**. We probably have to submit that one.

Mr. **Nagle**. I'm catching you cold.

Dr. **Fletcher**. Those are tough programs and I think you're right to zero in on those. We really have more work to do. We had to get the budget out and you're having the hearing pretty early, and we're doing the best we can. The ground facilities, though, are the ones that you need the generic legislation for and that's the one we're pressing for early decisions on.

Mr. **Nagle**. Now, if I could have the indulgence of the chair for one—I appreciate that. I mean, I'm not critical. I just don't want to go down the road we went down. But, if I could have the indulgence of the chair for just another 2 minutes.

I would like to ask you about the orbiter itself, not the engines, not the ASRM, not the RSRM. You know, not—none of that. I just want to talk about the orbiter itself.

Have you recently made any internal studies as to the structural soundness of the orbiter itself?

Dr. **Fletcher**. Well, I think I'd like to turn to the experts on that, but I'm sure we've made lots of studies on that one. In fact, we're doing it on a continuing basis.

What you have to do, Mr. Nagle, is look at the structural soundness under a wide variety of conditions, load conditions: landing——

Mr. **Nagle**. I'm particularly concerned about the wings and the fuselage.

Dr. **Fletcher**. Well, all right. The wings and the fuselage are vulnerable in several severe situations. Let me just put my opinion as to what the worse situations are. One is on landing. That's one very big stress on the fuselage and wings. Another one is as we go up through the the maximum dynamic pressure in the atmosphere, on launch. That's another major strain on the system. And then I think, in my judgment, the turn that they make, 1½ to 2 g's or so, prior to landing is also another strain on the system. Those have been thoroughly analyzed and re-analyzed because there's new factors coming up all the time.

Mr. **Nagle**. A question about those 3 that you've just described. Has there been a growing concern with any agency over the effect of wind and wind direction on the structural soundness? I'm using that term generically.

Dr. **Fletcher**. No. I think that's a good question because we ran into that problem on the last 2 flights, upper atmosphere winds.

George Abbey is here, and I'd like him to comment. Because I'm not an expert on structural problems, but George is closer to it.

George, do you want to try that?

Mr. Abbey. I think what you might be talking about is the loads analysis that we've been doing, and we have done——

Mr. Nagle. I'm sorry. I didn't catch the term you used.

Dr. Fletcher. Loads analysis.

Mr. Abbey. The loads analysis that we've done in NASA. That leads us to placard the orbiter for different wind conditions during launch, in particular. So we are placarding——

Dr. Fletcher. Placard means we have to put certain constraints on what we can do and what we can't do. That's a technical term.

Mr. Nagle. Sure.

Dr. Fletcher. George is technically oriented. [Laughter.]

Mr. Nagle. I thought you looked like a nice guy. [Laughter.]

Mr. Myers. What it boils down to——

Mr. Nagle. He's going to be gone, don't worry about him. You and I will get along. [Laughter.]

Mr. Myers. What it boils down to is there are times when we can't launch because we measure the wind and altitude, and if the wind is too high, we just don't launch under those conditions.

Mr. Nagle. Well, let's go ahead, though, with the load analysis if we can, just for a second. I mean, I'm hearing that there have been—there's been some studies that indicate that we may, in addition to focusing on an ASRM we may want to focus on the shuttle itself, or the orbiter itself, because of some reoccurring concerns over winds, wings, fuselage, and what I would call a tail. I'm sure there's a technical term for it.

Mr. Abbey. Well, we have certified the orbiter in a structural sense and, again, that has led—for certain conditions, wind conditions, we have what we call negative margins and that leads us into the situation under those wind conditions we wouldn't launch.

We also have within the last 2 years laid out a very detailed structural inspection program that we didn't have in the program before, so now we take the orbiter down after a certain number of flights and do a very detailed inspection of it.

Mr. Nagle. Would it be possible for the committee to get the results of those structural——

Mr. Abbey. Yes. We can——

Mr. Nagle [continuing]. Analyses?

Mr. Abbey. We can get those to you and point out or outline where we have those conditions.

[The information follows:]

Material requested for the record on page 85, line 2043, by Chrm. Nelson during the February 2, 1989, hearing at which Dr. Fletcher testified.

An updated Orbiter structural analysis was completed in April 1988. Over 60,000 orbiter components were analyzed and the detailed results of this analysis are contained in 120 volumes with over 110,000 pages. The vehicle capability derived from this analysis is documented in the "Orbiter Strength Summary and Flight Restrictions" (Document STS 88-0117). Flight operations within the conditions identified in this document assures that the orbiter structure has a 1.4 factor of safety for the imposed flight loads. The operations organization use this information in planning and conducting the NSTS missions.

On February 27, 1989, a briefing was presented to Dr. Harry S. "Terry" Dawson, Jr., Technical Consultant, Subcommittee on Space Science and Applications summarizing the Orbiter Structural Certification and Flight Operations. A copy of the briefing is attached for your information.

NSTS ENGINEERING INTEGRATION

Johnson Space Center, Houston, Texas

STRUCTURAL CERTIFICATION
OF THE
SPACE SHUTTLE

R. W. MOOREHEAD
NSTS ENGINEERING
02/27/89

NSTS ENGINEERING INTEGRATION

Johnson Space Center, Houston, Texas

Presenter R. W. Moorehead

Date 02/27/89

AGENDA

1.	INDUCED ENVIRONMENTS DEFINITION FOR STRUCTURAL CERTIFICATION	R. MOOREHEAD
2.	ORBITER STRUCTURAL CERTIFICATION	R. GLAYSHER R. GATTO
3.	DAY OF LAUNCH STRUCTURAL ASSESSMENT TO INSURE FLIGHT SAFETY	R. MOOREHEAD
4.	ADVANCED SOLID ROCKET MOTOR (ASRM)	R. MOOREHEAD

NSTS ENGINEERING INTEGRATION

Johnson Space Center, Houston, Texas

INDUCED ENVRIONMENT DEFINITION FOR STRUCTURAL CERTIFICATION

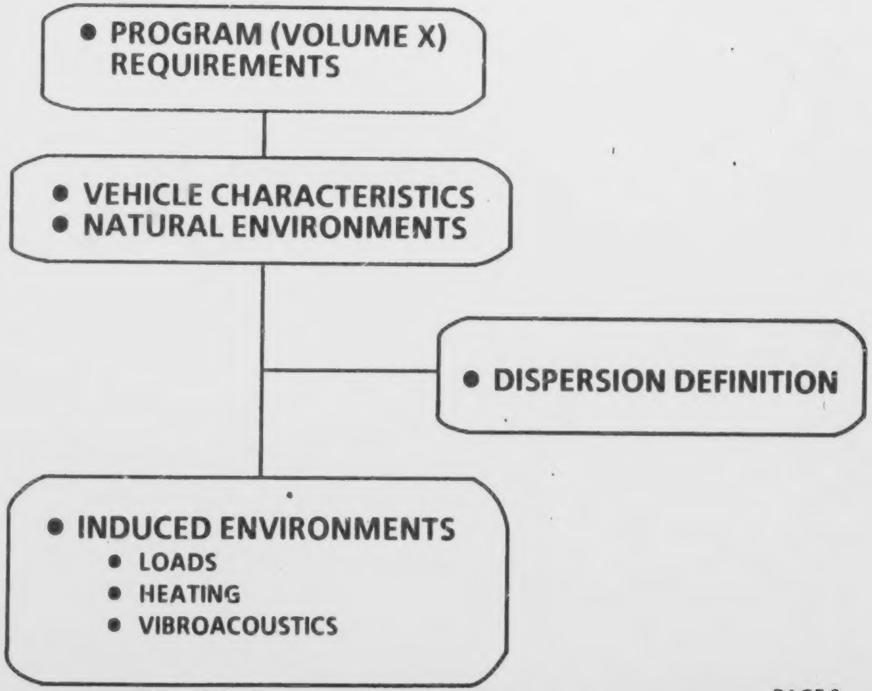
R. W. MOOREHEAD
NSTS ENGINEERING
02/27/89

NSTS ENGINEERING INTEGRATION

Johnson Space Center, Houston, Texas

INDUCED ENVIRONMENTS ESTABLISH CERTIFICATION DATA BASE

Presenter R. W. Moorehead
Date 02/27/89



- PROGRAM (VOLUME X) REQUIREMENTS

- VEHICLE CHARACTERISTICS
- NATURAL ENVIRONMENTS

- DISPERSION DEFINITION

- INDUCED ENVIRONMENTS
  - LOADS
  - HEATING
  - VIBROACOUSTICS

NSTS ENGINEERING INTEGRATION

Johnson Space Center, Houston, Texas

PARAMETERS AFFECTING INDUCED ENVIRONMENTS

Presenter R. W. Moorehead
Date 02/27/89

VOLUME X REQUIREMENTS

- REFERENCE MISSIONS
- INTACT ABORT MODES

VEHICLE CHARACTERISTICS

- MASS PROPERTIES
- THRUST PROFILE
- AERODYNAMICS
- AEROHEATING
- MODE SHAPE/FREQ
- PLUME THERMAL
- CONTROL SYSTEM
- SRB IGNITION TRANSIENT
- MLP STIFFNESS
- SRB STIFFNESS

NATURAL ENVIRONMENTS

- WINDS ALOFT
- GROUND WINDS
- ATMOSPHERE

DISPERSIONS

- WINDS
- ATMOSPHERE
- SYSTEMS
- WIND PERSISTENCE

NSTS ENGINEERING INTEGRATION

Johnson Space Center, Houston, Texas

SHUTTLE CERTIFIED PRIOR TO FIRST FLIGHT

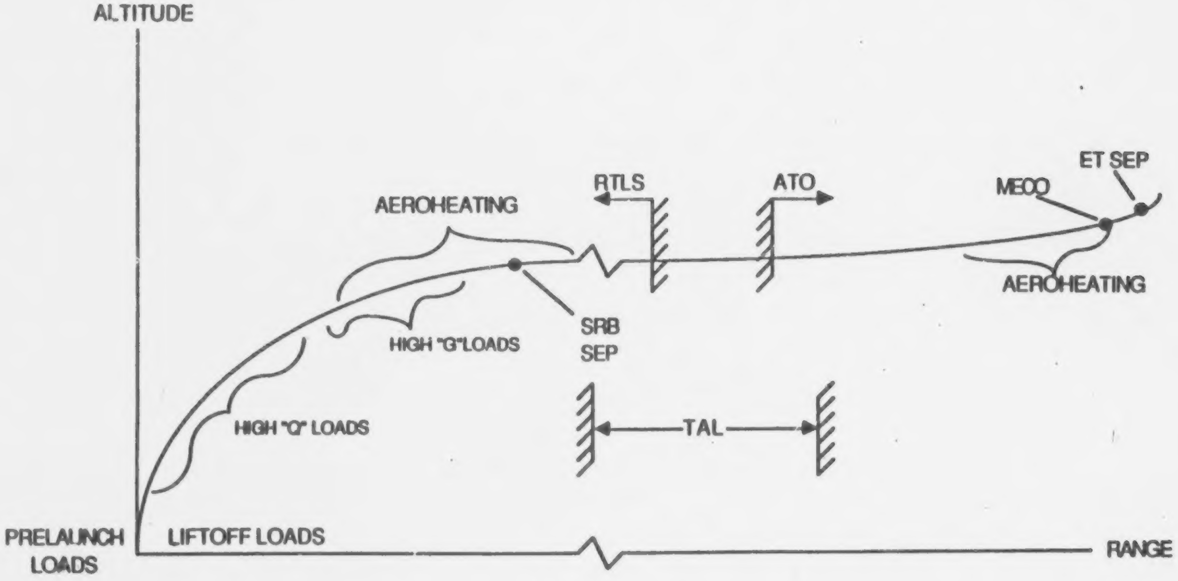
Presenter R. W. Moorehead

Date 02/27/89

- SPACE SHUTTLE VEHICLE CERTIFIED TO PREDICTED INDUCED ENVIRONMENTS PRIOR TO FIRST FLIGHT (STS-1)
  - IVBC-2 ENVIRONMENTS (INTEGRATED VEHICLE BASELINE CHARACTERIZATION -2)
  - BASED ON ANALYSIS, GROUND TEST, AND WIND TUNNEL TEST DATA
- STS-1 IDENTIFIED SIGNIFICANT HOT PLUME EFFECT ON VEHICLE AERODYNAMICS
  - WING CARRIED MORE LIFT THAN EXPECTED
  - MEASUREMENTS TAKEN DURING FIRST 5 FLIGHTS
  - LEAD TO REDEFINITION OF WING PRESSURE DISTRIBUTIONS

INTEGRATED VEHICLE INDUCED ENVIRONMENTS

- LOADS
- HEATING
- VIBROACOUSTICS


ALTITUDE
AEROHEATING
RTLS
ATO
ET SEP
MECO
AEROHEATING
SRB SEP
HIGH "G" LOADS
HIGH "Q" LOADS
TAL
PRELAUNCH LOADS
LIFTOFF LOADS
RANGE

NSTS ENGINEERING INTEGRATION

Johnson Space Center, Houston, Texas

SHUTTLE FLIGHT DESIGN MODIFIED TO PROTECT ORBITER WING

Presenter R. W. Moorehead
Date 02/27/89

- NEW FLIGHT TRAJECTORY DESIGN REQUIRED TO UNLOAD WING AND FLY WITHIN STRUCTURAL CAPABILITY
  - TRAJECTORIES DESIGNED TO MORE NEGATIVE ANGLES OF ATTACK (α)
  - WING LIFT EQUALS ZERO DURING ASCENT AT ABOUT $\alpha = -7^\circ$
- ANALYSIS ACCOMPLISHED TO PROVIDE INITIAL DEFINITION OF ORBITER CONSTRAINTS WHEN FLYING NEW TRAJECTORY DESIGNS
  - OCA-D (ORBITER CAPABILITY ASSESSMENT - PHASE D)

NSTS ENGINEERING INTEGRATION

Johnson Space Center, Houston, Texas

SHUTTLE RECERTIFICATION REQUIRED

Presenter R. W. Moorehead
Date 02/27/89

- NEW STRUCTURAL CERTIFICATION PROGRAM REQUIRED
  - WING PRESSURES DIFFERENT
  - FILAMENT WOUND CASE (FWC) SRB'S INTRODUCED
  - VAFB LAUNCH DEFINITION IMPROVED
- NEW INDUCED ENVIRONMENTS TERMED IVBC-3
  - ENVIRONMENTS DEFINED FOR ALL PHASES OF FLIGHT
  - ENVIRONMENTS INCLUDED LOADS, THERMAL, VIBROACOUSTIC, ETC.
- ELEMENT PROJECTS TASKED TO RECERTIFY THEIR STRUCTURES TO IVBC-3
  - ORBITER PROGRAM TERMED VEHICLE 6.0 ANALYSIS (V6.0)
  - EFFORT IN PROGRESS WHEN STS-51L ACCIDENT OCCURRED
    - NSTS PROGRAM DECIDED TO CERTIFY ORBITER TO LESS SEVERE OCA-D ENVIRONMENTS
  - OTHER ELEMENTS CERTIFIED TO IVBC-3 ENVIRONMENTS

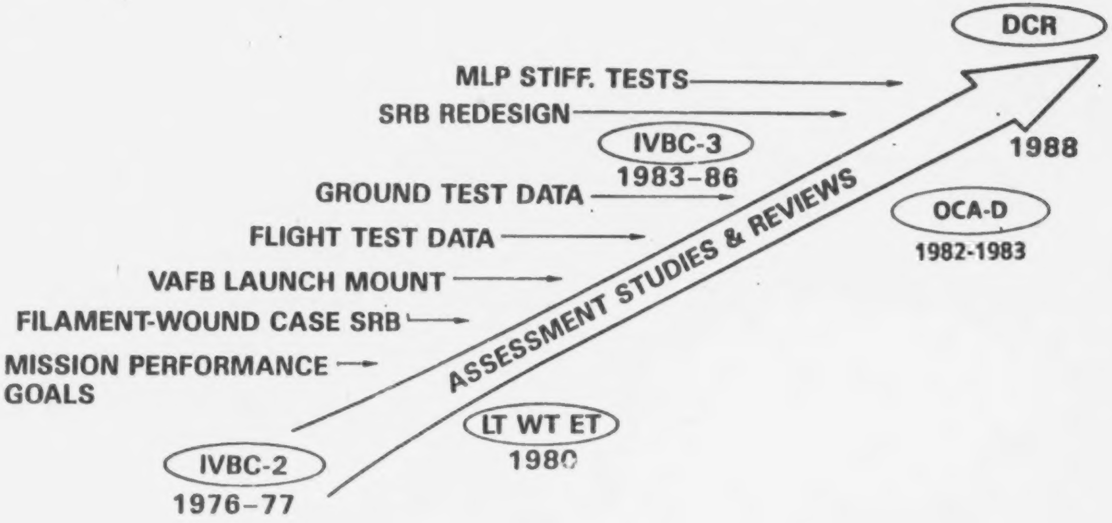
FINAL CERTIFICATION ACCOMPLISHED PRIOR TO RETURN-TO-FLIGHT

Presenter R. W. Moorehead

Date 02/27/89

- SUBSEQUENT TO STS-51L ACCIDENT, ADDITIONAL SPACE SHUTTLE CHANGES ADDRESSED
  - SRB REDESIGN
    - AFT SKIRT STIFFNESS DEFINED BY TEST
    - SRM PRESSURE RISE RATES DEVELOPED FROM FLIGHT HISTORY
    - ADDITIONAL PROTUBERANCES DESIGNED
  - MLP STIFFNESS
    - REDEFINED BY TEST
- FLIGHT ENVIRONMENTS UPDATED AND ISSUED TO ELEMENT PROJECTS
  - STRUCTURAL RECERTIFICATIONS COMPLETED AND REVIEWED AT DESIGN CERTIFICATION REVIEW (DCR) PRIOR TO RETURN TO FLIGHT (STS-26R)

Integrated Vehicle Analyses Have Assessed Changes to the Design Data Base



DCR

MLP STIFF. TESTS

SRB REDESIGN

IVBC-3
1983–86

1988

GROUND TEST DATA

FLIGHT TEST DATA

OCA-D
1982-1983

VAFB LAUNCH MOUNT

FILAMENT-WOUND CASE SRB

ASSESSMENT STUDIES & REVIEWS

MISSION PERFORMANCE
GOALS

LT WT ET
1980

IVBC-2
1976–77

IVBC = INTEGRATED VEHICLE BASELINE CHARACTERIZATION

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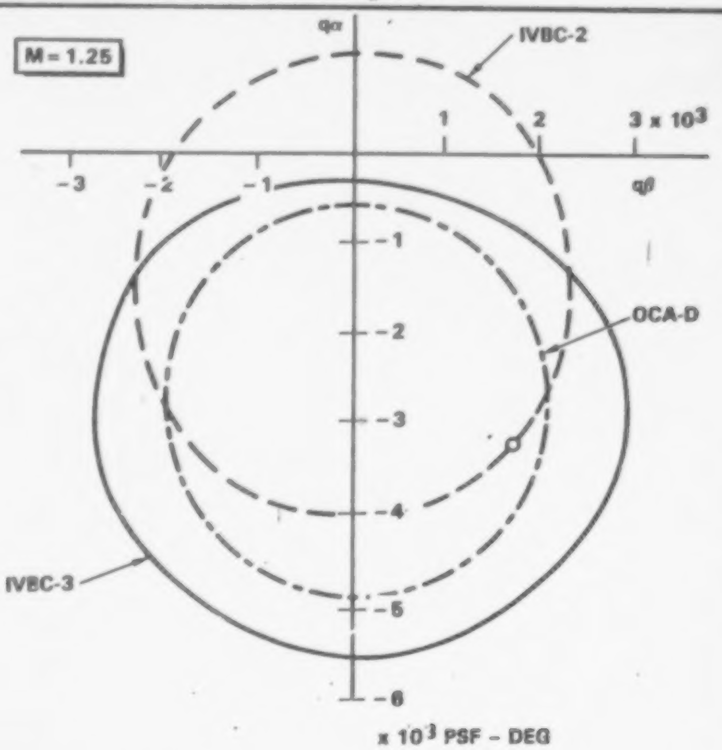
Comparison of Flight Envelopes



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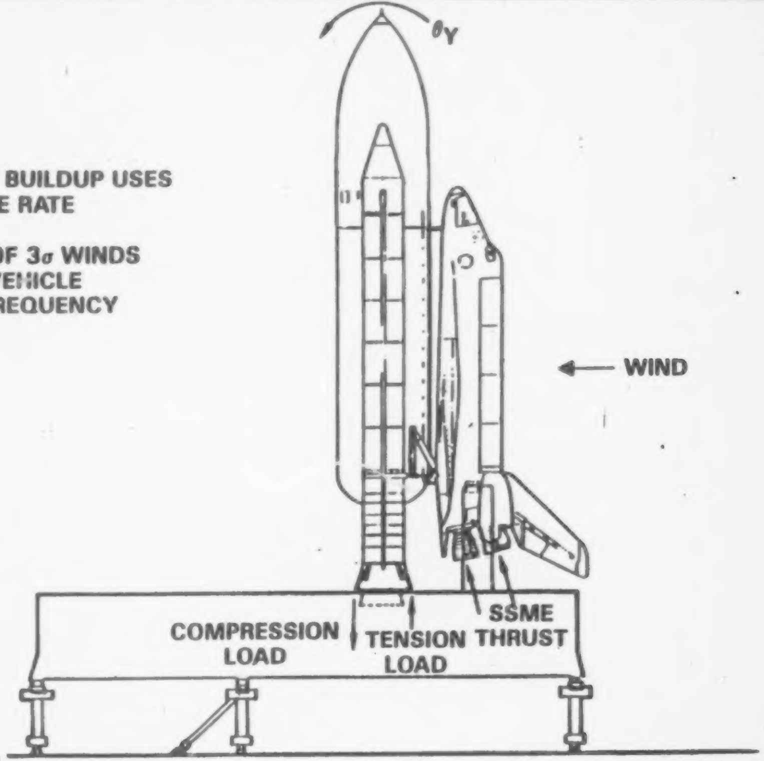
Prelaunch Dynamic Loads

- SSME THRUST BUILDUP USES MAXIMUM RISE RATE
- GUST SHAPE OF 3σ WINDS IS TUNED TO VEHICLE PITCH-OVER FREQUENCY


θ_Y
WIND
SSME THRUST
COMPRESSION LOAD
TENSION LOAD

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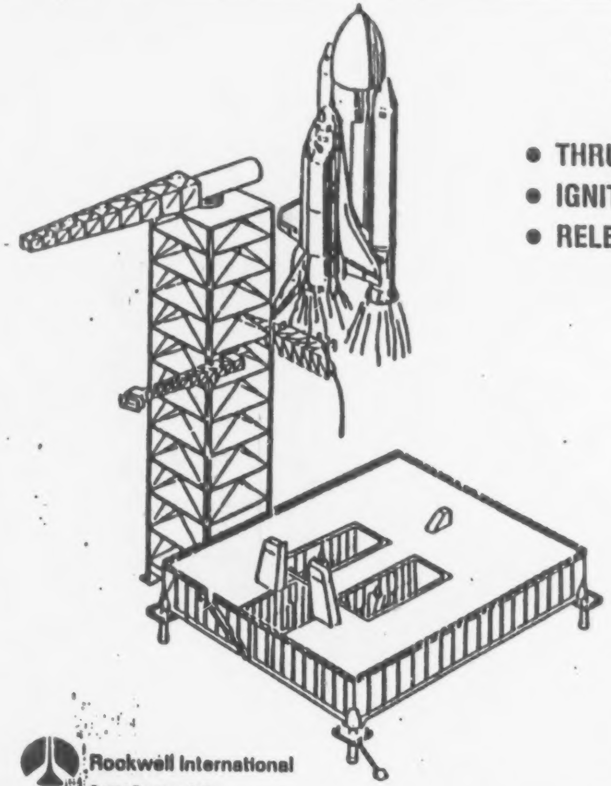
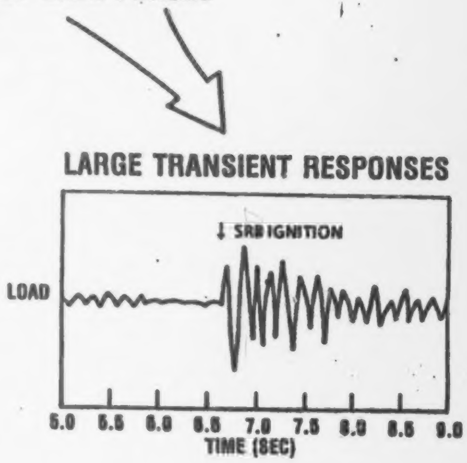
36S8V212481

Liftoff Dynamic Loads



- THRUST BUILDUP
- IGNITION OVERPRESSURE
- RELEASE OF BASE FORCES



LARGE TRANSIENT RESPONSES

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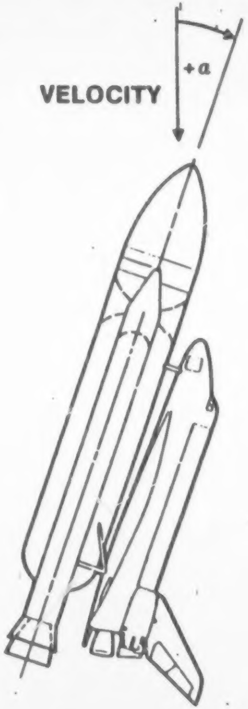
[illegible]

High Q Boost Loads Analysis



- DYNAMIC RESPONSE OF VEHICLE DUE TO WIND SHEAR & GUST, & CONTROL SYSTEM RESPONSE
- NO FAILURE & ONE-SSME-OUT CONDITIONS
- DESIGN REFERENCE MISSIONS: 1, 2, 3A, 3B
- WINTER & SUMMER CONDITIONS
- SSME THROTTLING SCHEDULE
- ACTIVE LOAD RELIEF ELEVONS
- DISPERSIONS:
  - ELEVON POSITION
  - ROTATIONAL ACCELERATIONS
  - SRB THRUST LEVEL
  - SRB THRUST ALIGNMENT
  - SRB THRUST MISMATCH
  - AERODYNAMIC TOLERANCES
    - VEHICLE ELEMENT COEFFICIENTS
    - ELEVON HINGE MOMENT COEFFICIENTS

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3855V177221A

Orbiter Structural Certification

February 27, 1989

R.M. Glaysher
Vice President, Engineering
Space Transportation
Systems Division

Rockwell
International

Orbiter Structural Certification

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- INTRODUCTION
- CRITERIA
- CERTIFICATION TECHNIQUE
- RESULTS OF ANALYSIS
  - ASCENT
  - DESCENT
- CERTIFIED BOUNDARIES
  - ANALYSIS
  - CONSTRAINTS
  - RECOMMENDATIONS
- OPEN WORK
- SUMMARY

Conclusions

- OV-103/OV-104 STRUCTURALLY OK FOR FUTURE FLIGHTS BUT MUST STAY WITHIN DEFINED CONSTRAINTS
- REAL WORLD DATA SHOWS WE HAVE OPERATED WELL WITHIN FLIGHT ENVELOPES
- LAUNCH PROBABILITY OF 70-80% IS REAL WORLD — 95% WAS TARGET
- OV-102 NEEDS ADDITIONAL ANALYSIS
- ON-GOING ACTIVITIES WILL ENHANCE LAUNCH PROBABILITY

Orbiter Structural Certification

OBJECTIVE

- TO SHOW THAT THE LARGE MAJORITY OF ORBITER STRUCTURES IS CERTIFIED TO THE INTEGRATED VEHICLE BASELINE CHARACTERIZATION 3RD REVISION (IVBC-3) 6.0 LOADS ENVELOPE
- TO IDENTIFY 5 STRUCTURAL COMPONENTS THAT CANNOT SUPPORT 6.0 LOADS & TO OUTLINE PLAN TO RESOLVE THOSE STRUCTURAL ISSUES

Objective of IVBC-3/6.0 Loads Is to Recover and Expand Orbiter Performance

- FLIGHT DATA FROM STS-1 THRU STS-5 SHOWED HIGHER ASCENT LOADS ON WING & AFT FUSELAGE & HIGHER DESCENT THERMAL LOADS THAN ANTICIPATED
- TRAJECTORY SHAPING INVOKED TO PROTECT WING
- TRAJECTORY SHAPING RESULTED IN REDUCED OVERALL PERFORMANCE
- NEW/REVISED PROGRAM REQUIREMENTS INFLUENCED CREDIBILITY OF 5.4 LOADS DATA BASE
  - COMPARTMENT VENTING & LEAKAGE
  - AERODYNAMIC DISTRIBUTIONS
  - INERT & USABLE WEIGHT DISTRIBUTIONS
  - GROSS LANDING WEIGHTS
  - UPDATE OF AERO SHOCK ENVIRONMENTS
  - VAFB LAUNCH PAD STIFFNESS
  - VAFB IGNITION OVER PRESSURE
  - FILAMENT WOUND CASE — SRB

NEW LOADS CYCLE REQUIRED TO ACCOUNT FOR FLIGHT DATA & ENCHANCED PERFORMANCE REQUIREMENTS

Participants in 6.0 Loads/Stress Analysis

- ROCKWELL — DOWNEY
  - AEROHEATING ANALYSIS
  - THERMAL ANALYSIS
  - STRESS ANALYSIS:
    - FORWARD FUSELAGE
    - CREW MODULE
    - WINGS*
    - TPS TILES
    - MECHANISMS
- ROCKWELL — TULSA
  - PAYLOAD BAY DOORS
- LTV/VOUGHT — DALLAS
  - NOSE CAP
  - WING LEADING EDGE
- MENASCO — BURBANK
  - LANDING GEAR

  - COMPARTMENT VENTING
  - DESCENT STRUCTURAL LOADS

    - MID FUSELAGE*
    - AFT FUSELAGE/THRUST STRUCTURE
    - VERTICAL TAIL*
    - WINDOWS
    - SECONDARY STRUCTURE
- ROCKWELL — COLUMBUS
  - BODY FLAP
- McDONNELL DOUGLAS — ST. LOUIS
  - OMS PODS
- NASA — JSC

*ANALYSIS PERFORMED BY ROCKWELL — NOT MANUFACTURER

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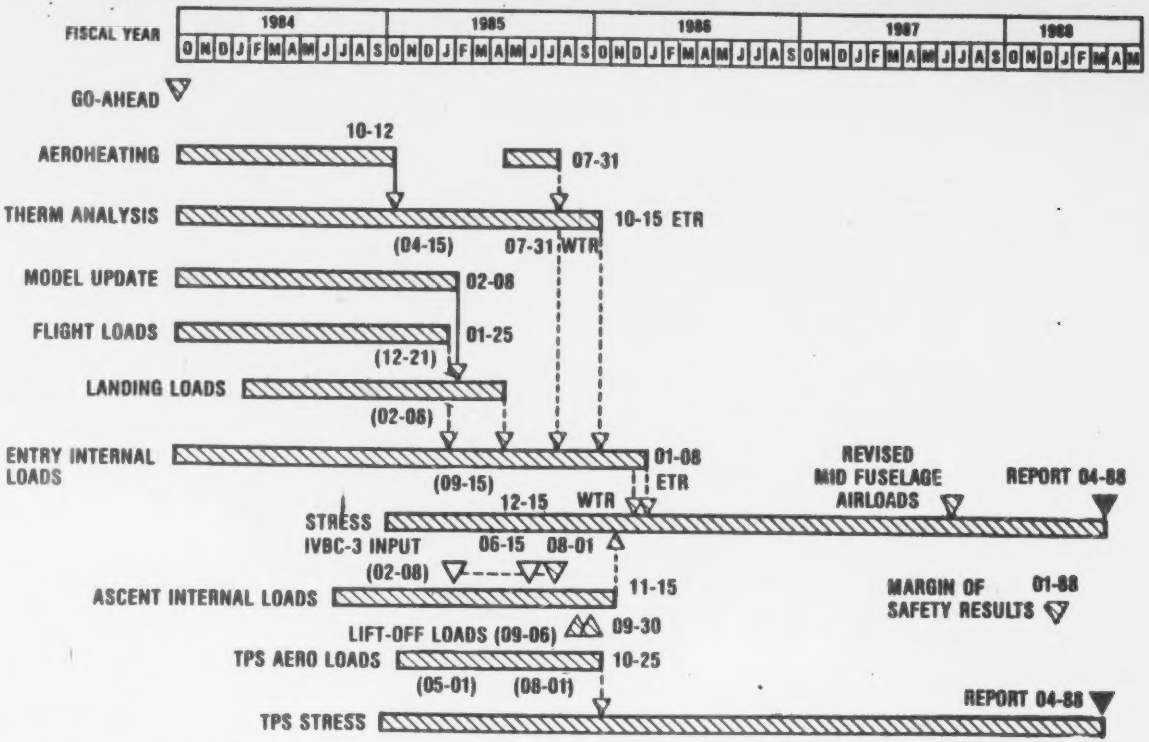
6.0 Loads/Stress Cycle — Nearing Completion



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2835V197331A

IVBC-3/6.0 Loads Criteria Established to Push Orbiter Capability to Its Limits

PARAMETER	ANALYSIS CRITERIA	
	IVBC-2/5.4 LOADS 1976-80	IVBC-3/6.0 LOADS 1984-88
$q\alpha$ (PSF — DEG)	+2400 TO −3900	+1200 TO −5600
$q\beta$ (PSF — DEG)	± 2500	±2900
NOMINAL TRAJECTORY q (PSF — DEG)	−1500	−3000
MAX q (PSF)	790	819
q — MACH NO. RANGE	SEE CHART — PAGE 64a	SEE CHART — PAGE 64a
AERODYNAMICS	WIND TUNNEL IA135/IA81	WIND TUNNEL IA105/IA300 PLUS OFT FLIGHT DATA
LIFT-OFF*	ETR/STEELCASE SRB ANALYTICAL SRB OVERPRESSURE	ETR/STEELCASE SRB WTR/FILAMENT WOUND CASE SRB FLIGHT DERIVED SRB OVERPRESSURE
PROBABILITY OF LAUNCH	95%	95%

* DCR — 2 & 3 ANALYSIS PENDING

IVBC-3/6.0 Loads Criteria Established to Push Orbital Capability to Its Limits

PARAMETER	ANALYSIS CRITERIA	
	IVBC-2/5.4 LOADS	IVBC-3/6.0 LOADS
GROSS WEIGHT (LB)		
• ASCENT	256,800	276,500
• END OF MISSION	211,000	214,000
• RTLS	240,000	256,000
• AOA	240,000	248,000
• TAL	NOT DEFINED	250,000
AEROTHERMAL	ONE TRAJECTORY	3 TRAJECTORIES
	6 INITIAL SUN ORIENTATION	6 INITIAL SUN ORIENTATION
	OV-102 TPS CONFIGURATION	OV-103 TPS CONFIGURATION
	ANALYTICAL MATH MODELS	ANALYTICAL + FLIGHT DERIVED MATH MODELS
ORBITER CONFIGURATION	OV-102 STRUCTURE/TPS	OV-103 STRUCTURE/TPS
WING ANALYSIS	IVBC-2 FLIGHT ENVELOPE	"OCA-D" FLIGHT ENVELOPE

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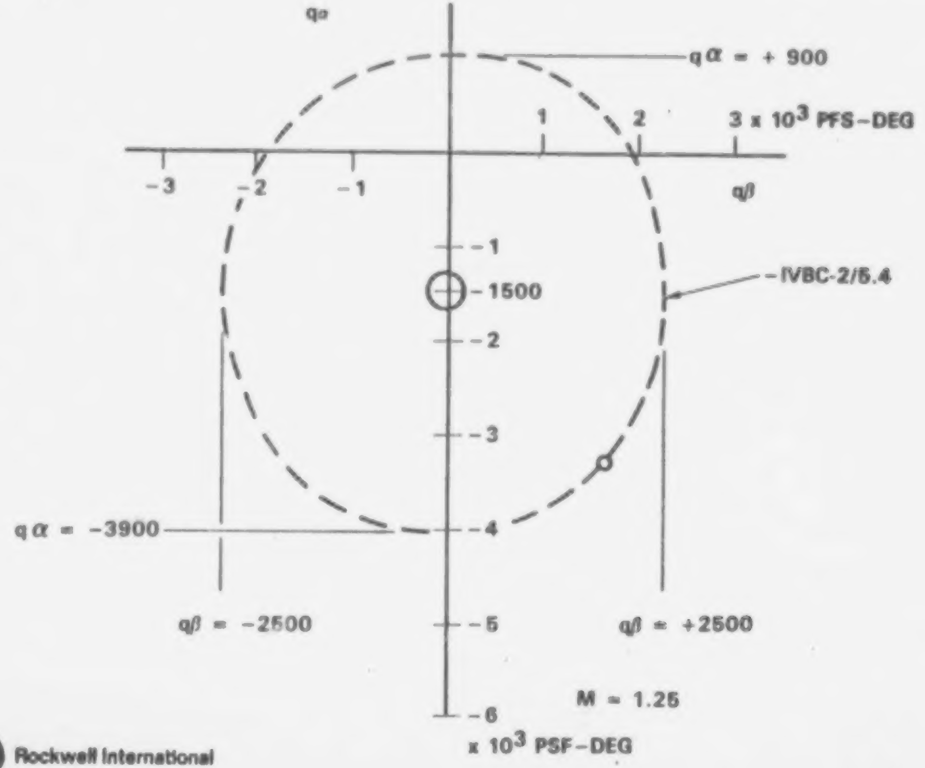
28SSV210445

Graphic Representation of Flight Envelope Is by Use of a Squatcheloid



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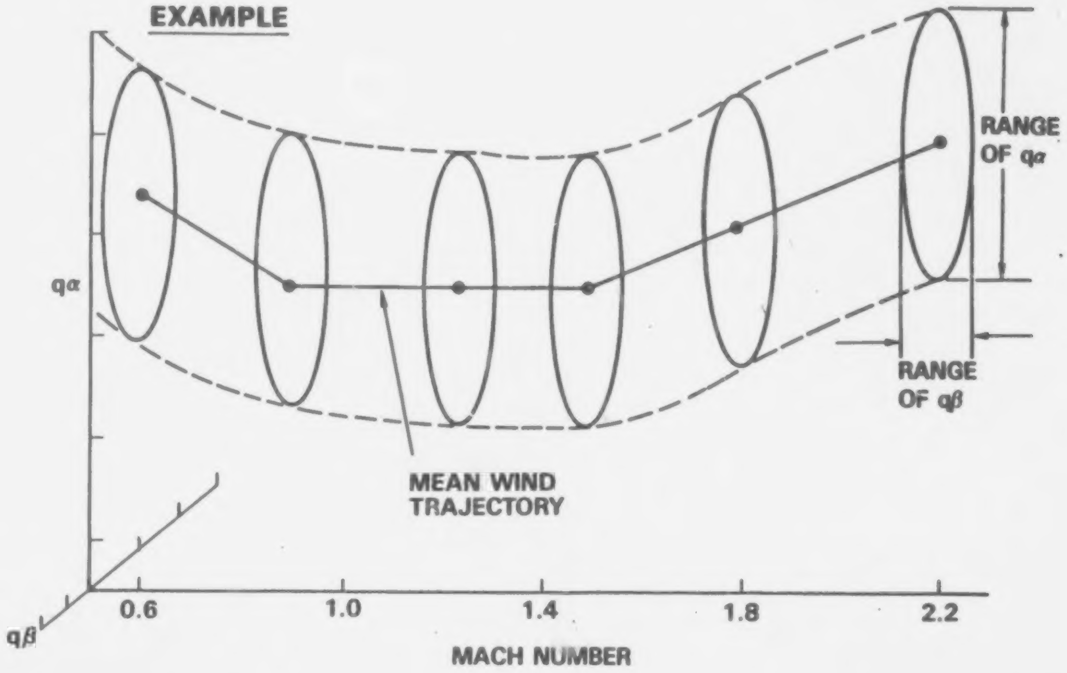
29SSV211760A

Family of Squatcheloids Represent Flight Conditions

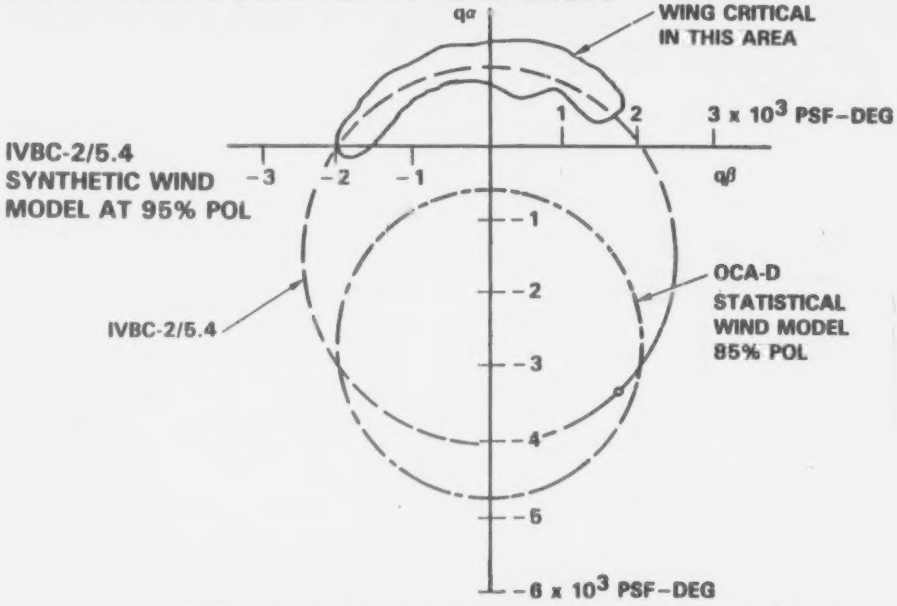

EXAMPLE
qα
qβ
RANGE OF qα
RANGE OF qβ
MEAN WIND TRAJECTORY
0.6
1.0
1.4
1.8
2.2
MACH NUMBER

Rockwell International
Space Transportation Systems Division

29SSV211765

Revised Flight Envelope Required to Preclude Wing Load Exceedences

- FLIGHT DATA SHOWED HIGHER ASCENT WING LOADS THAN ANTICIPATED FOR IVBC-2/5.4 LOAD CASES



- EFFECT OF OCA-D FLIGHT ENVELOPE WAS TO:
  - REDUCE PAYLOAD LIFTING CAPACITY
  - REDUCE POL

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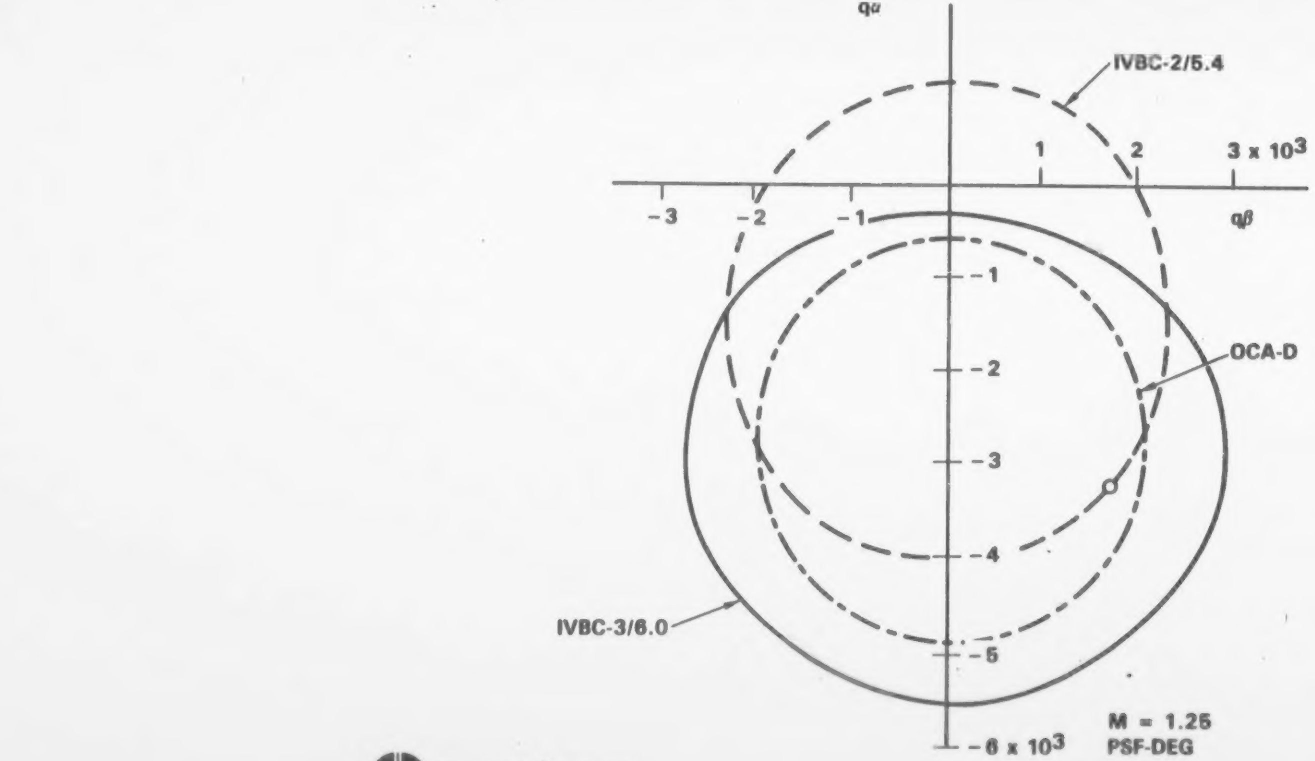
Systems Division

IVBC-3/6.0 Load Flight Envelope Defined to Determine Limits of Vehicle and Recover Lost Performance



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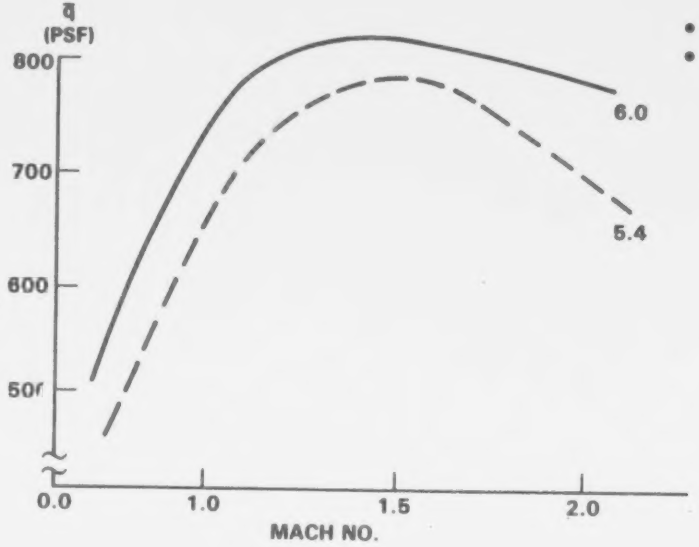
Space Transportation
Systems Division

28SSV211784

Higher $\overline{q}$'s Exist Over Critical Mach Range



Effects

- HIGHER AERODYNAMIC LOADS
- DIFFERENT VENTING PRESSURES

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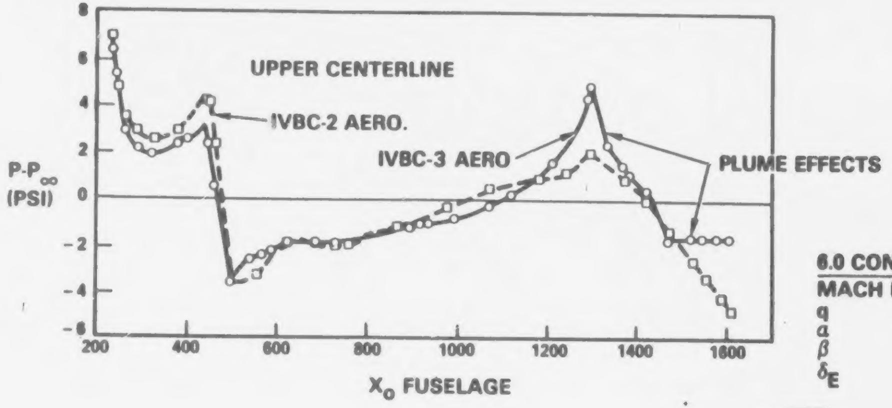
Space Transportation
Systems Division

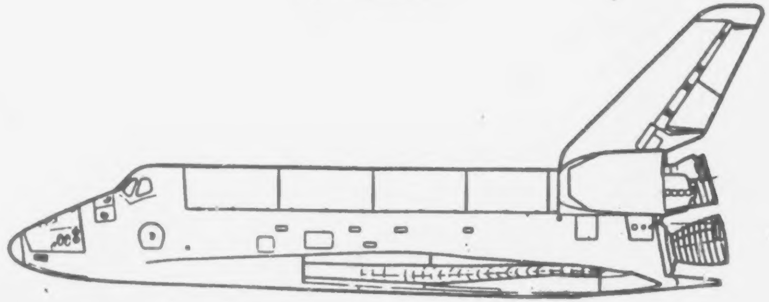
2855V211762

Top Centerline Mid-Fuselage External Pressures Generally Remained Unchanged OMS Pod Area Sees Dramatic Increase



6.0 CONDITION 345

MACH NO. = 1.05
q = 752 PSF
α = −5.73 DEG
β = −2.95 DEG
δ_E = 10/9 DEG



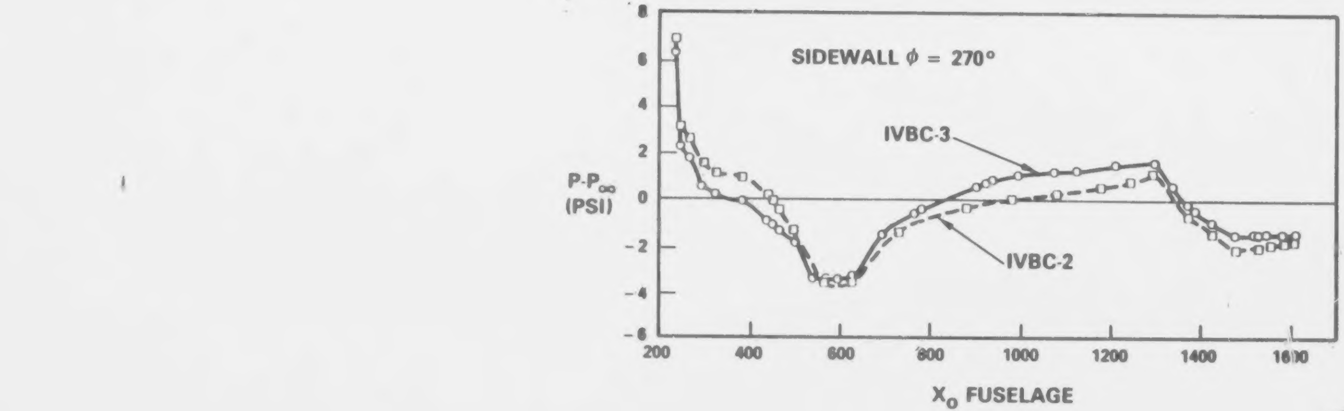
DATA SOURCE

WIND TUNNEL + ANALYSIS

Rockwell International
Space Transportation Systems Division

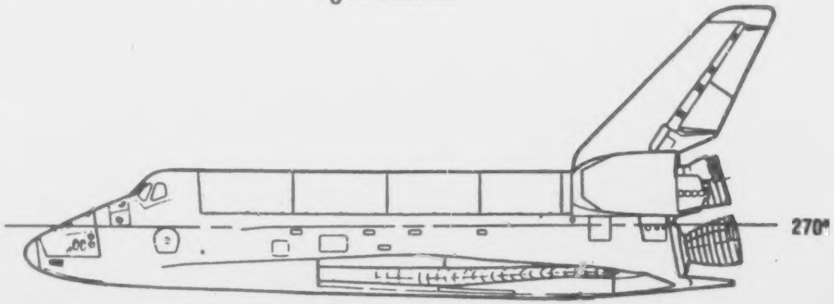
28SSV206267B

External Pressures Increased Over Mid and Aft Fuselage Sidewalls



6.0 CONDITION

MACH NO. = 1.05
q = 752 PSF
α = −5.73 DEG
β = −2.36 DEG
δ_E = 10/9 DEG



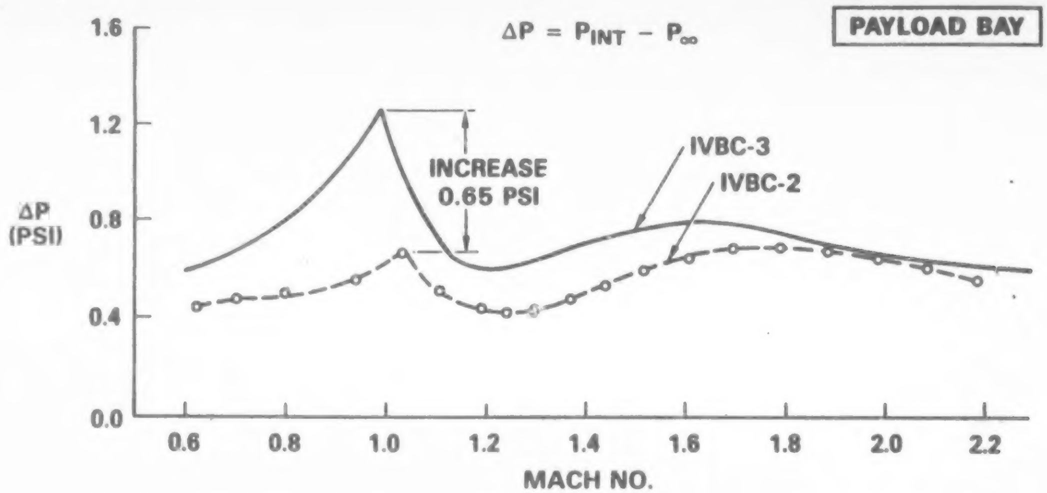
DATA SOURCE

WIND TUNNEL +
ANALYSIS +
FLIGHT DATA

Rockwell International
Space Transportation
Systems Division

28SSV2062868

Changes in Dynamic Pressure $\bar{q}$ and Local External Pressure Resulted in 0.65 PSI Increase in Compartment Pressure



COMPARTMENT PRESSURE INCREASE DUE TO

- INCREASED DYNAMIC PRESSURE
- MORE NEGATIVE ANGLE-OF-ATTACK
- INCREASED ANALYSIS TOLERANCE 0.35 vs 0.25 PSI

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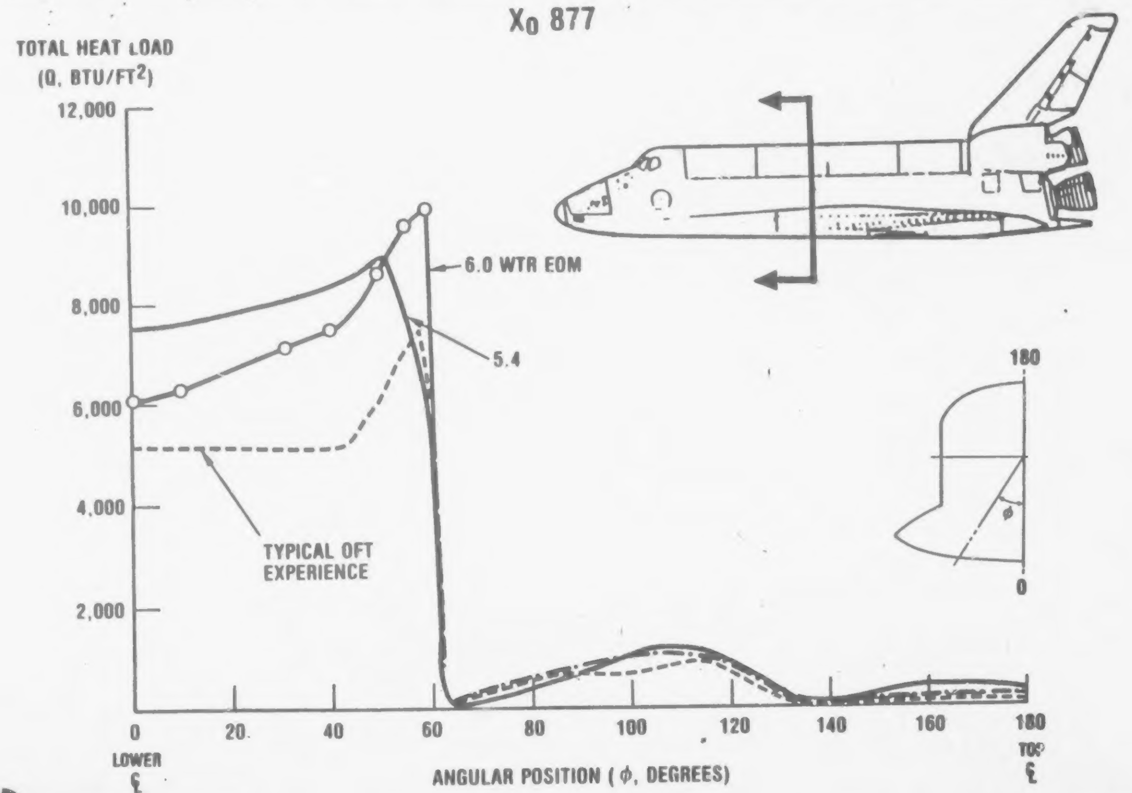
Systems Division

28SSV2059168

Aeroheating and Thermal Gradients Have Increased



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Space Transportation Systems Division

28SSV142369C

Certification Technique

Rockwell International
Space Transportation
Systems Division

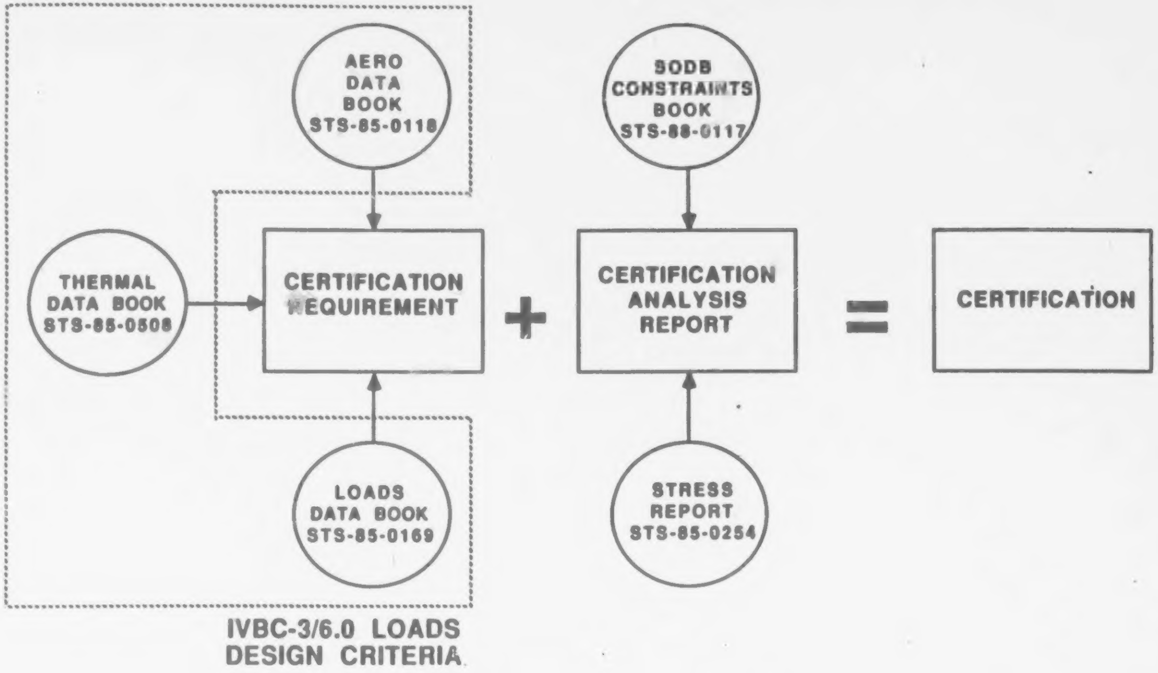
Certification Combines Analysis and Constraints

- CERTIFICATION APPROACH
  - STRUCTURAL ELEMENTS WHICH HAVE POSITIVE MARGINS TO THE IVBC-3/6.0 LOADS DATABASE ARE CERTIFIED TO THAT DATABASE

PLUS

  - STRUCTURAL ELEMENTS WHICH DO NOT HAVE POSITIVE MARGINS TO THE IVBC-3/6.0 LOADS DATABASE ARE CERTIFIED TO A SERIES OF CONSTRAINTS IN THE FORM OF REDUCED SQUATCHELOIDS & MODIFIED V-N DIAGRAMS

Certification Documentation Consists of Data Books Stress Analyses and Constraints Book



THERMAL DATA BOOK STS-85-0508

AERO DATA BOOK STS-85-0118

LOADS DATA BOOK STS-85-0169

CERTIFICATION REQUIREMENT

+

SODB CONSTRAINTS BOOK STS-88-0117

STRESS REPORT STS-85-0254

CERTIFICATION ANALYSIS REPORT

=

CERTIFICATION

IVBC-3/6.0 LOADS DESIGN CRITERIA

Results

Scope of Analysis Included 60,000 Structural Components

- 60,000 COMPONENTS ANALYZED
- 30 MAJOR STRUCTURAL ELEMENTS INVOLVED
  - NOSE CAP
  - LOWER FORWARD FUSELAGE
  - UPPER FORWARD FUSELAGE
  - FORWARD RCS
  - CREW MODULE
  - TPS
  - PLBD (4)
  - MID-FUSELAGE
  - WINGS
  - AFT FUSELAGE
  - TAIL
  - HEAT SHIELD
  - WING LEADING EDGE
  - OMS PODS
  - ELEVONS (2)
  - BODY FLAP
  - WINDOWS
  - MLG DOOR SETS (2)
  - NLG DOORS
  - LANDING GEAR (2)
  - RUDDER/SPEED BRAKE (2)
  - ET ATTACH STRUCTURE (2)

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Space Transportation
Systems Division

28SSV210237

6 Previous Structural Modifications Incorporated to Expand Vehicle Capability to IVBC-3/6.0 Loads

• MOMENT TIES FOR LEADING EDGE	09-83
• WING STRUCTURAL UPGRADES TO OCA-D	
• WING/FUSELAGE BOLTS	10-85
• WING/FUSELAGE SPLICE DOUBLER	04-86
• DOUBLERS ON WING COVER, SPAR WEBS	03-86
• LOCATION 'A' TILES	05-87
• MID FUSELAGE	
• RTV LOWER SURFACE	04-87
• 18 STRUTS	11-87
• 3 HINGE FITTINGS	11-87
• FASTENERS AT 12 HINGES	11-87
• OMS POD-FITTING NO. 6 BOLT UPGRADE	12-87
• ORBITER/ET ATTACH BOLT	12-87

Analysis Results Show Majority of Structure Has Positive Margins — 25 Major Structural Elements

- 30 MAJOR STRUCTURAL ELEMENTS INVOLVED
- 5 MAJOR STRUCTURAL ELEMENTS REMAIN WITH NEGATIVE MARGIN COMPONENTS
  - WING — ASCENT/DESCENT 20 OF 2,000 PARTS
  - AFT FUSELAGE — ASCENT 16 OF 550 PARTS
  - TAIL — ASCENT 15 OF 300 PARTS
  - OMS PODS — ASCENT/DESCENT 3 OF 200 PARTS
  - WING LEADING EDGE — DESCENT 18 OF 930 PARTS

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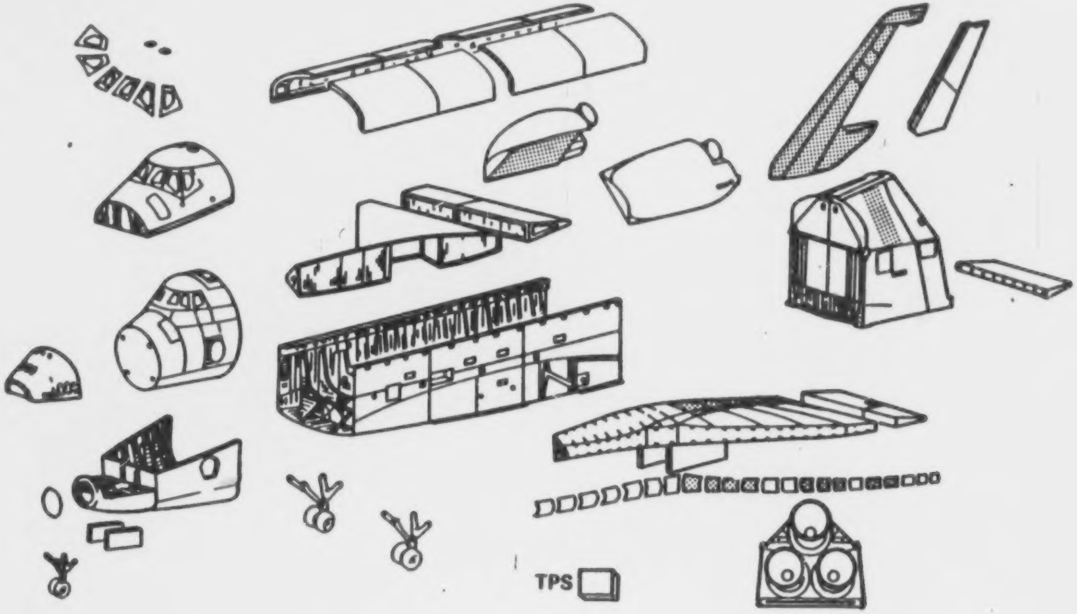
Systems Division

285SV210239

26 Major Structural Elements Fully Cleared for IVBC-3/6.0 Loads



R NOT CLEARED
G CLEARED

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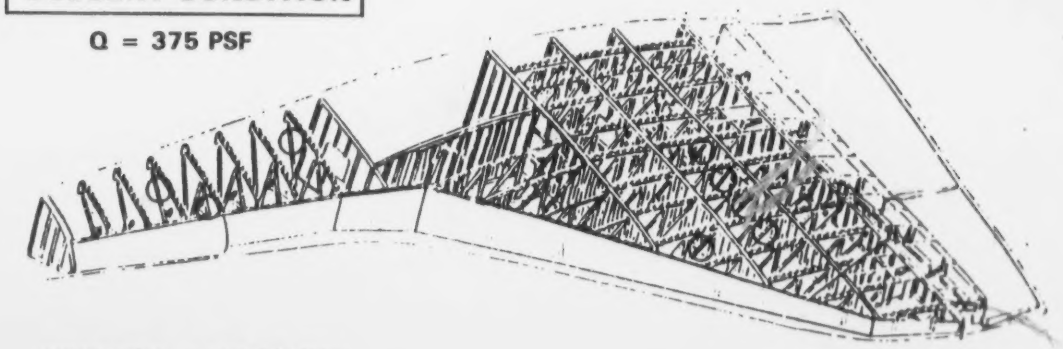
Space Transportation
Systems Division

29SSV210248A
BK-7

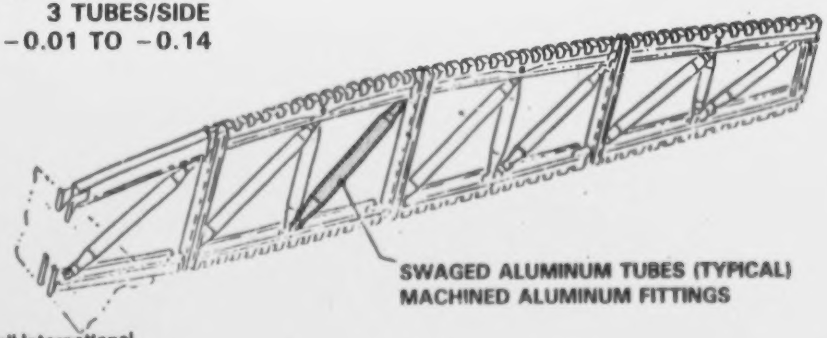
Wing Truss Tubes
Structural Negative Margin Components Identified

DESCENT CONDITION

Q = 375 PSF



WING BOX 5 TUBES/SIDE
GLOVE 3 TUBES/SIDE
M.S. = −0.01 TO −0.14


SWAGED ALUMINUM TUBES (TYPICAL)
MACHINED ALUMINUM FITTINGS

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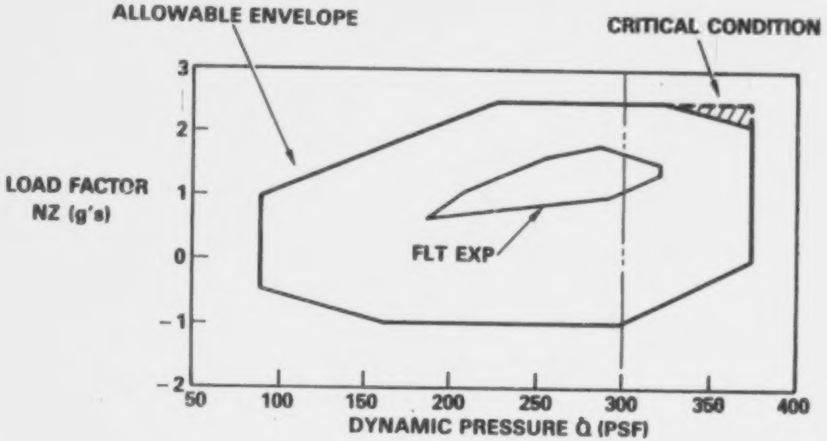
Space Transportation
Systems Division

Critical Load Condition Identified for the Wing

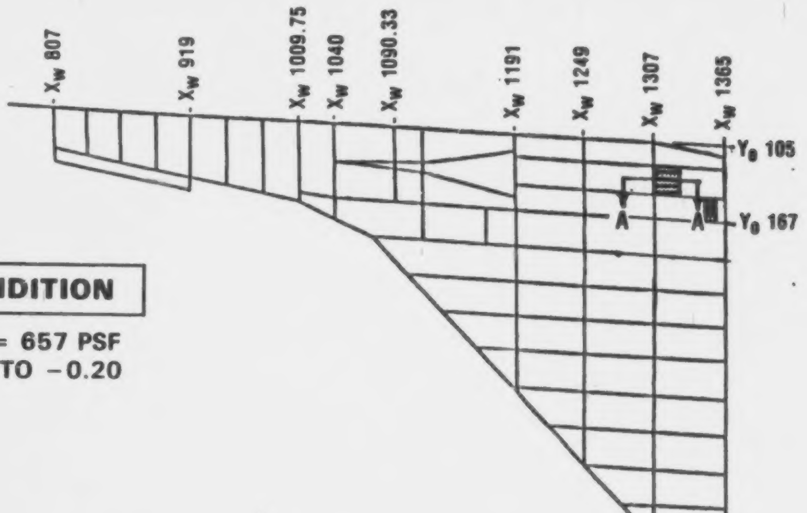
STEADY PITCH V-n DIAGRAM FOR MACH = 0.80

- EXCESSIVE AIRLOADS ON WING TRUSS TUBES
- NORMAL FLTS PLANNED AT 300 PSF OR LESS



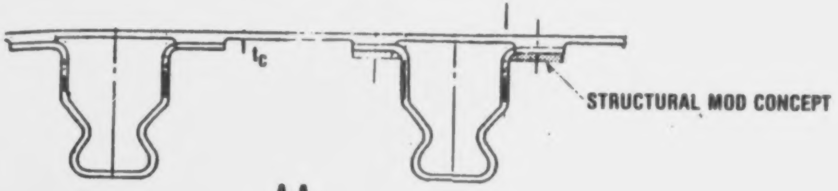
Rockwell International
Space Transportation Systems Division

Wing Upper Cover Stiffener Structural Negative Margin Components Identified


X_w 807
X_w 919
X_w 1009.75
X_w 1040
X_w 1090.33
X_w 1191
X_w 1249
X_w 1307
X_w 1365
Y_0 105
Y_0 167
A
A

ASCENT CONDITION

M = 1.25 Q = 657 PSF
M.S. = −0.01 TO −0.20


t_c
STRUCTURAL MOD CONCEPT

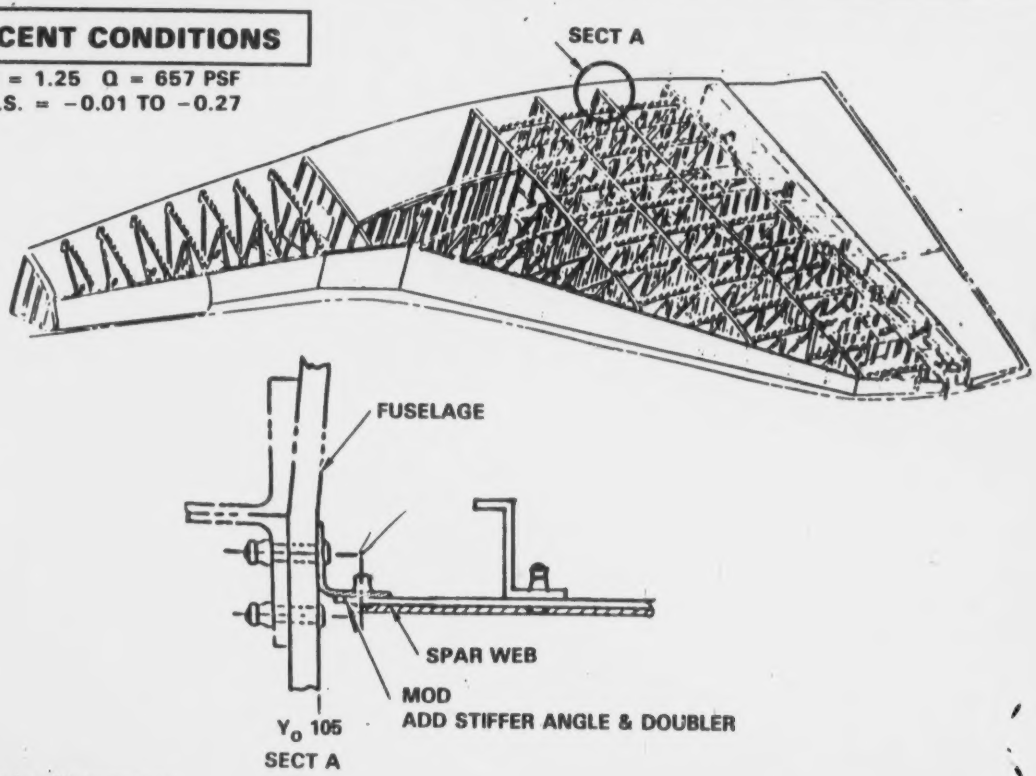
A-A

Rockwell International
Space Transportation
Systems Division

X_o Spar Interface
Structural Negative Margin Component Identified

ASCENT CONDITIONS

M = 1.25 Q = 657 PSF
M.S. = −0.01 TO −0.27


SECT A
FUSELAGE
SPAR WEB
MOD
ADD STIFFER ANGLE & DOUBLER
Y_o 105
SECT A

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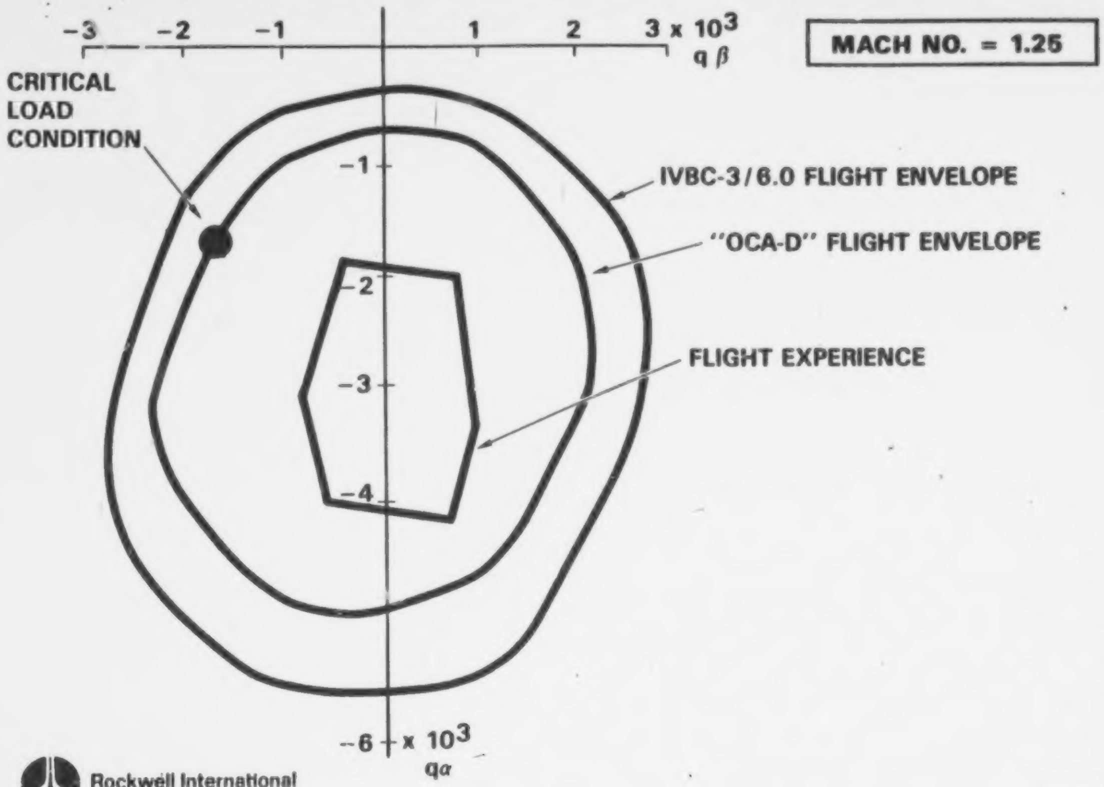
Space Transportation
Systems Division

106SSV2104508
BK-13

Critical Load Condition Identified for the Wing



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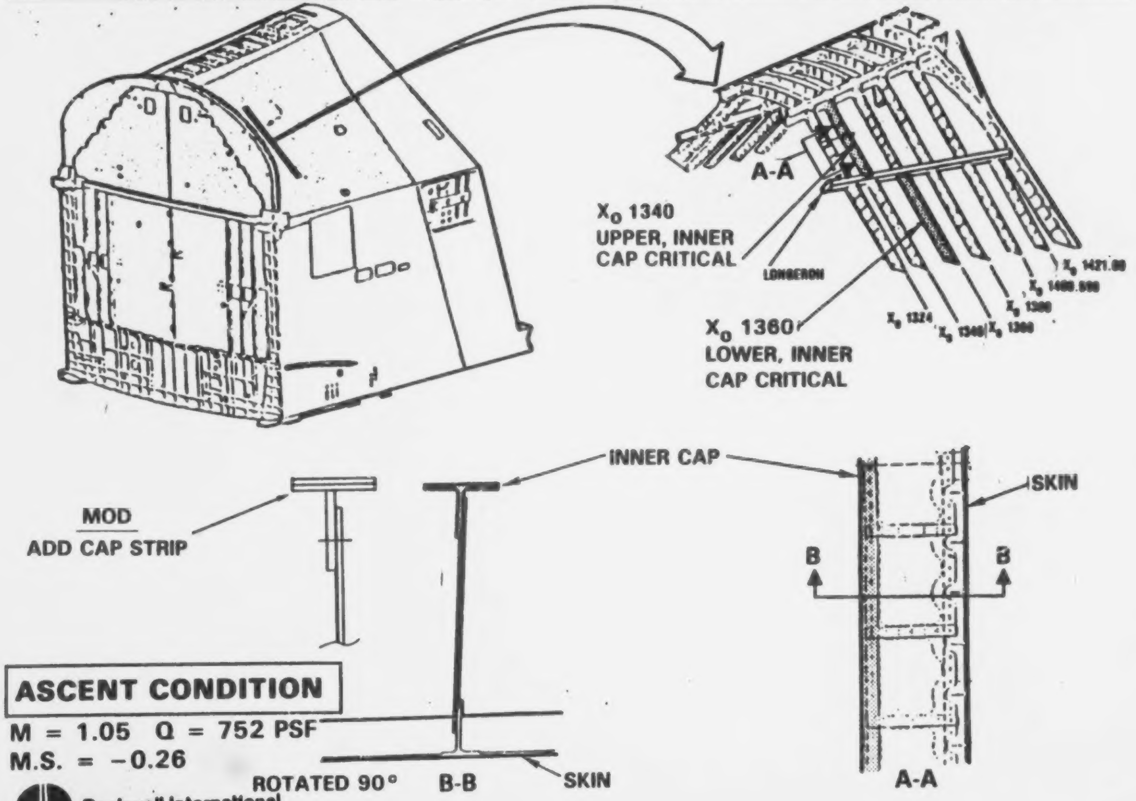
Space Transportation
Systems Division

29SSV195223D

OMS Deck Frames
Structural Negative Margin Components Identified


A-A
X_o 1340
UPPER, INNER
CAP CRITICAL
LONGERON
X_o 1360
LOWER, INNER
CAP CRITICAL
X_o 1421.00
X_o 1400.000
X_o 1380
X_o 1324
X_o 1340
X_o 1360
INNER CAP
SKIN
B
B
A-A
MOD
ADD CAP STRIP
ROTATED 90°
B-B
SKIN

ASCENT CONDITION

M = 1.05 Q = 752 PSF
M.S. = −0.26

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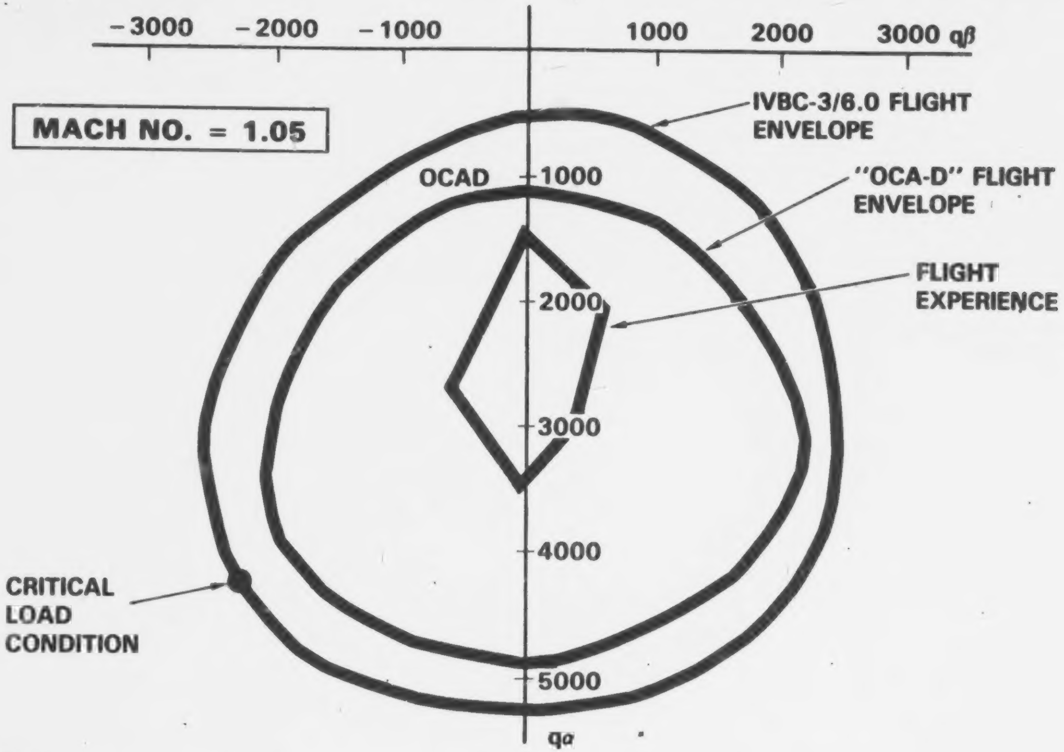
Systems Division

28SSV210411A

Critical Load Condition Identified for the OMS Deck Frames



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Space Transportation
Systems Division

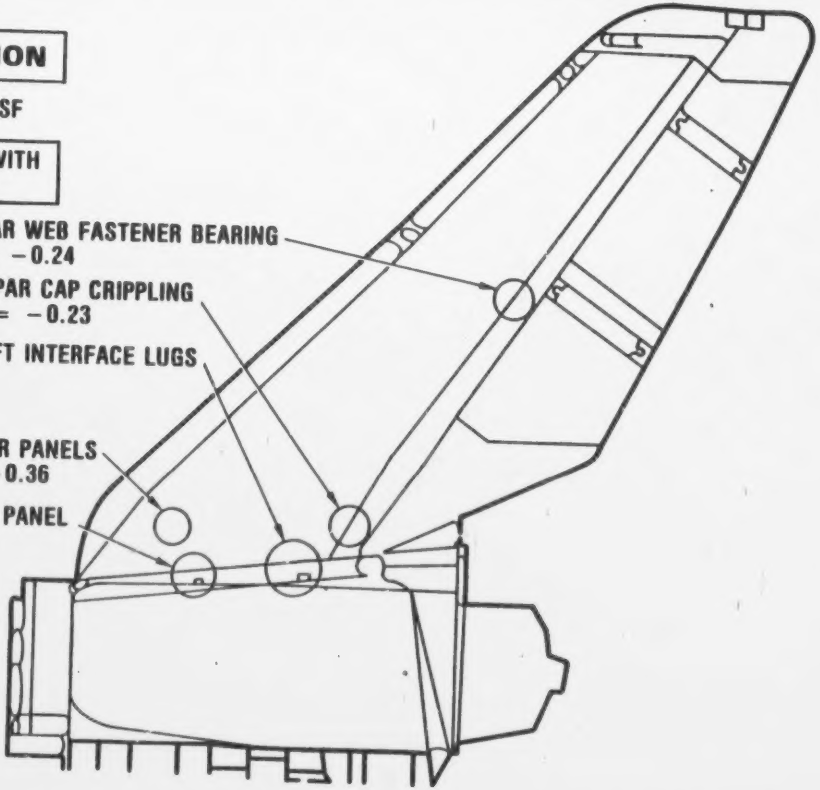
28SSV211816

Vertical Tail
Structural Negative Margin Components Identified

ASCENT CONDITION

M = 1.25 Q = 767 PSF

NEW ANALYSIS IN PROCESS WITH RE-DEFINED (LOWER) LOADS



AFT SPAR WEB FASTENER BEARING
M.S. = −0.24

AFT SPAR CAP CRIPPLING
M.S. = −0.23

TAIL/FUSELAGE AFT INTERFACE LUGS
M.S. = −0.25

TAIL COVER PANELS
M.S. = −0.36

ROOT RIB BEADED PANEL
M.S. = −0.31

MOD

UNDEFINED BUT
SELECTIVE MODS
CAN INCREMENTALLY
CHANGE POL

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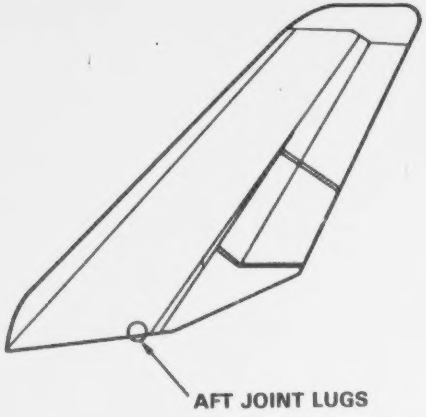
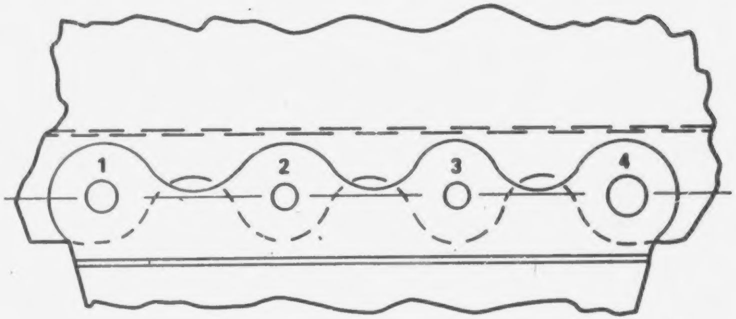
Space Transportation
Systems Division

29SSV197351C

Vertical Tail Joint Lugs
Structural Negative Margin Components



- **REMEDY**
  - REDESIGN FITTING WITH INCREASED LUG THICKNESS &/OR BOLT DIAMETER
  - FUSELAGE FITTING MUST BE MODIFIED TO ACCOMMODATE CHANGES TO TAIL



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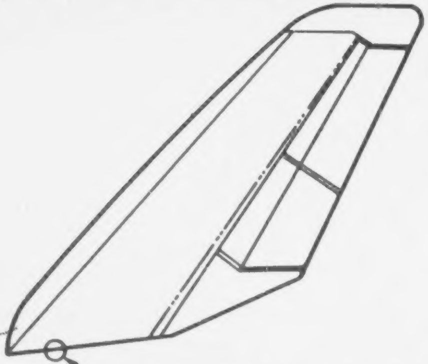
Systems Division

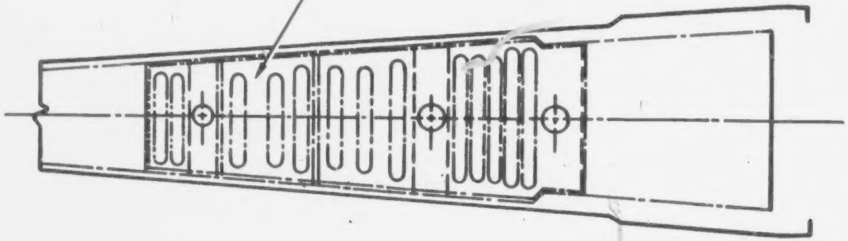
28SSV211388

Vertical Tail Root Rib
Structural Negative Margin Components



ROOT RIB FORWARD BEADED PANEL

- **REMEDY**
  - REPLACE BEADED PANEL WITH MACHINED WAFFLE PANEL



BEADED PANEL BUCKLING DUE TO SHEAR

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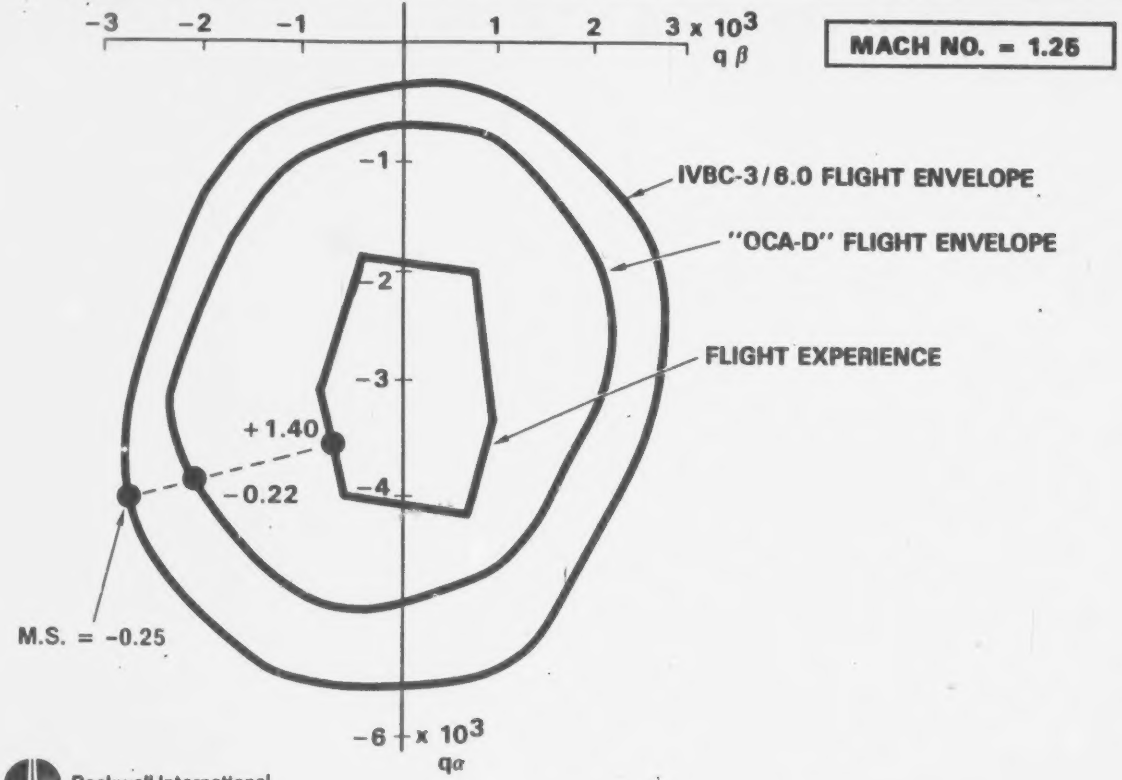
Systems Division

28SSV211387

Critical Load Condition Identified for Vertical Tail



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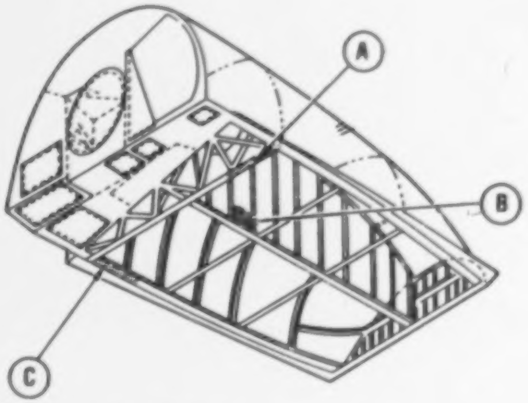
Systems Division

28SSV211812

OMS POD
Structural Negative Margin Components Identified



RIGHT SIDE POD

A. AFT BULKHEAD FLOOR MEMBER
  - DESCENT LANDING CONDITION: 9.6 FT/SEC
  - REMEDY: DOUBLER

B. CENTERLINE KEEL WEB/LONGERON
  - ASCENT BOOST CONDITION: M = 1.55
    Q = 765 PSG
  - DRAG/INERTIA LOAD
  - REMEDY: ADD FITTINGS

C. INBOARD LONGERON
  - ASCENT BOOST CONDITION: M = 1.55
    Q = 765 PSG
  - SIDELOAD
  - REMEDY: DOUBLER

- FLIGHT CONSTRAINT: 71% OF MAXIMUM CONSUMABLES WEIGHT
- LANDING CONSTRAINT: 15% OF MAXIMUM CONSUMABLES WEIGHT OR REDUCE SINK SPEED TO 8.0 FT/SEC

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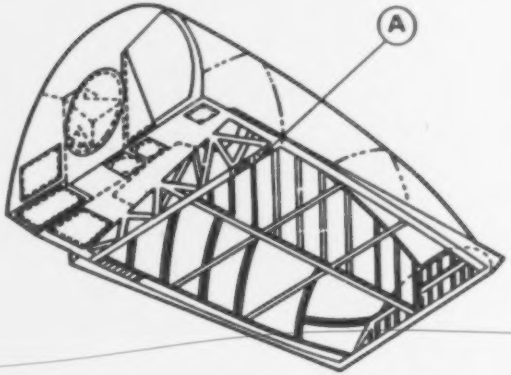
Space Transportation
Systems Division

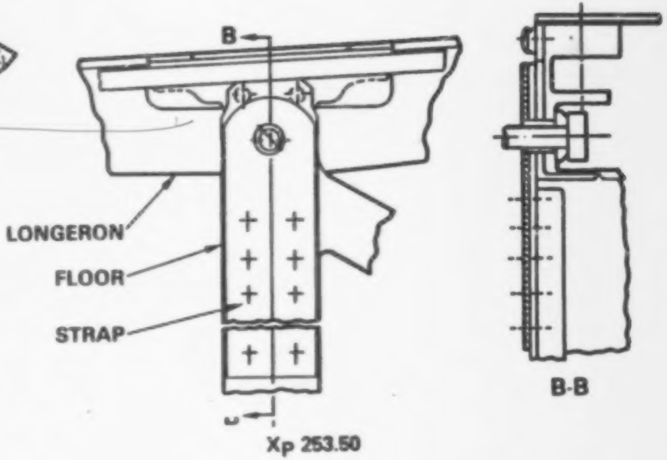
38SSV206229C

OMS POD — Structural Modifications Being Developed

A. AFT BULKHEAD FLOOR MEMBER
- REMEDY: DOUBLER



RIGHT SIDE POD


B
B
LONGERON
FLOOR
STRAP
Xp 253.50
B-B

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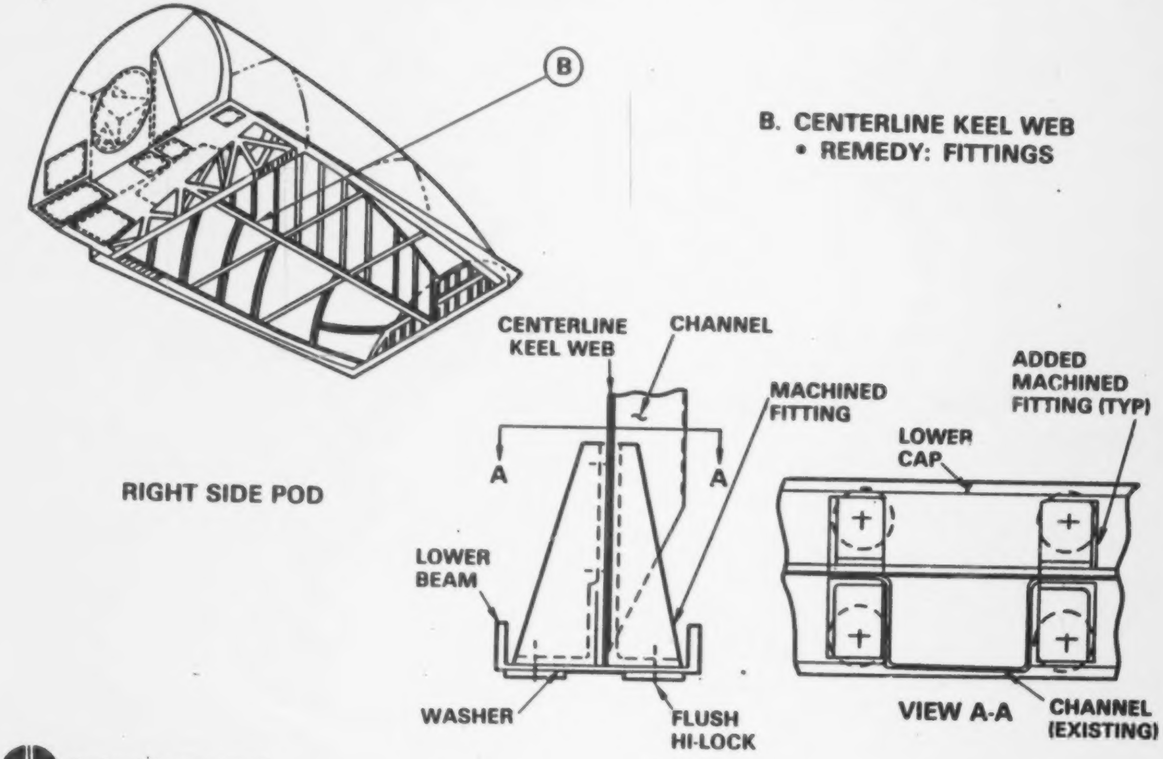
Systems Division

38SSV212618

OMS POD — Structural Modifications Being Developed

B. CENTERLINE KEEL WEB
- REMEDY: FITTINGS


B
RIGHT SIDE POD
CENTERLINE KEEL WEB
CHANNEL
MACHINED FITTING
A
A
LOWER BEAM
WASHER
FLUSH HI-LOCK
ADDED MACHINED FITTING (TYP)
LOWER CAP
VIEW A-A
CHANNEL (EXISTING)

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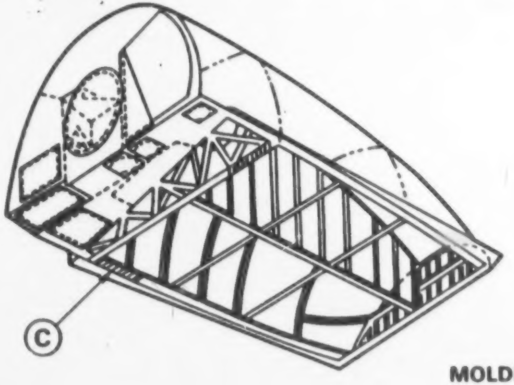
Space Transportation Systems Division

38SSV212617

OMS POD — Structural Modifications Being Developed

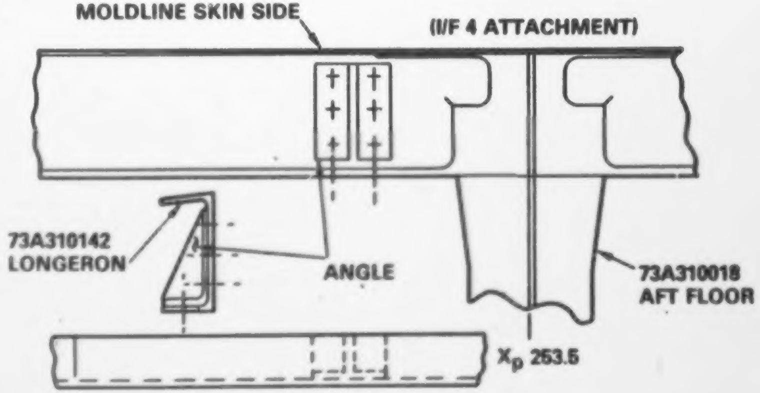


RIGHT SIDE POD

C. INBOARD LONGERON
- REMEDY: ANGLE

3 REMEDIES

DESIGN RELEASE: 04-15-88
KIT AVAILABLE: 05-18-88 (FIRST)
06-17-88 (FLEET)


MOLDLINE SKIN SIDE
(I/F 4 ATTACHMENT)
73A310142
LONGERON
ANGLE
73A310018
AFT FLOOR
X_p 253.5

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Space Transportation
Systems Division

38SSV212816

Wing Leading Edge Panel Structural Negative Margin Component Identified

DESCENT CONDITION

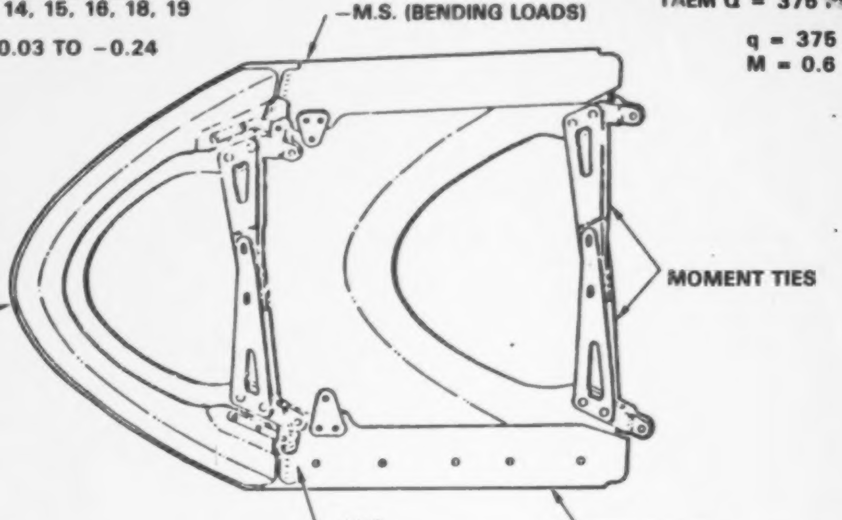
TAEM Q = 375 PSF

q = 375 PSF
M = 0.6

9 OF 22 PANELS

8, 9, 10, 11, 14, 15, 16, 18, 19

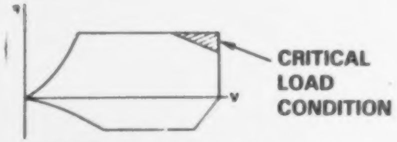
M.S. = −0.03 TO −0.24



–M.S. (BENDING LOADS)
MOMENT TIES
RCC GAP SEAL
–M.S.
RCC PANEL

RANGE OF M.S. = −0.03 TO −0.24

REMEDY



REVISE V-n DIAGRAM

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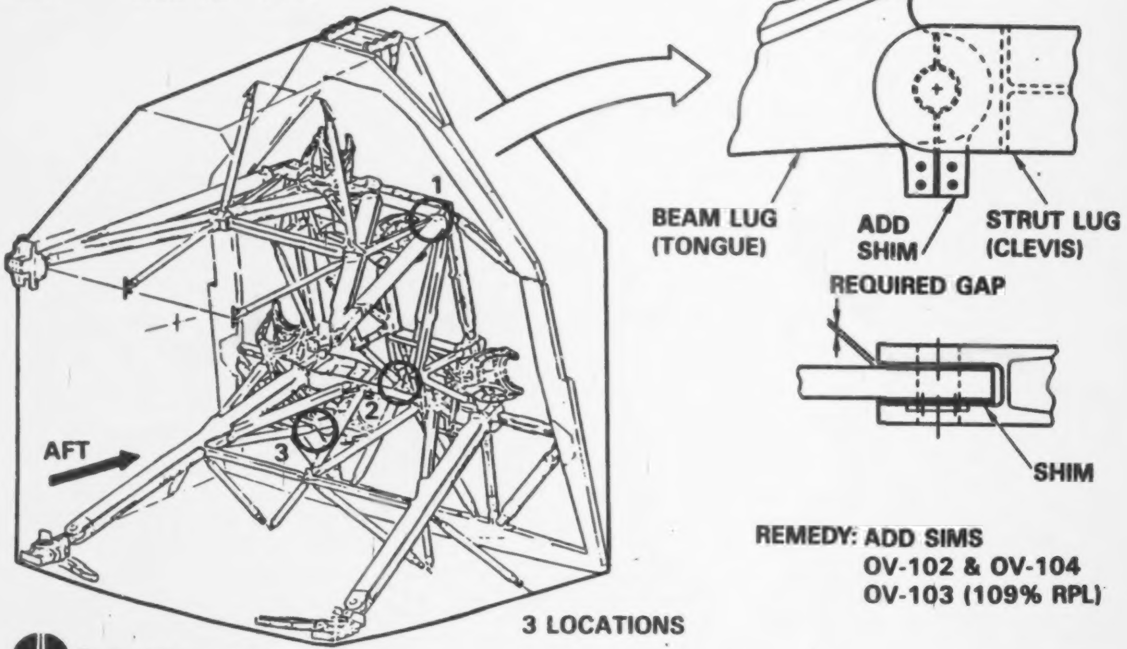
Space Transportation Systems Division

10&SV210447B
3K-15

Thrust Structure Lugs Structural Negative Margin Component Identified

ASCENT CONDITION

ONE-SSME-OUT NEAR SRB STAGING
M.S. = −0.02 TO −0.11


1
2
3
AFT
3 LOCATIONS
BEAM LUG (TONGUE)
ADD SHIM
STRUT LUG (CLEVIS)
REQUIRED GAP
SHIM

REMEDY: ADD SIMS
OV-102 & OV-104
OV-103 (109% RPL)

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38SSV211813A

Certified Baseline

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Certified Baseline Has Been Defined

25 MAJOR STRUCTURAL ELEMENTS HAVE BEEN FULLY CLEARED FOR IVBC-3/6.0 LOADS

- NOSE CAP
- LOWER FWD FUSELAGE
- RCS MODULE
- UPPER FWD FUSELAGE
- CREW MODULE
- MID FUSELAGE
- WING ELEVONS (2)
- RUDDER/SPEED BRAKES (2)
- HEAT SHIELD
- LANDING GEAR (2)
- BODY FLAP
- NLG DOORS
- MLG DOORS (2)
- PAYLOAD BAY DOORS (4)
- TPS
- ET ATTACH STRUCTURE
- AFT FUSELAGE SHELL
- WINDOWS

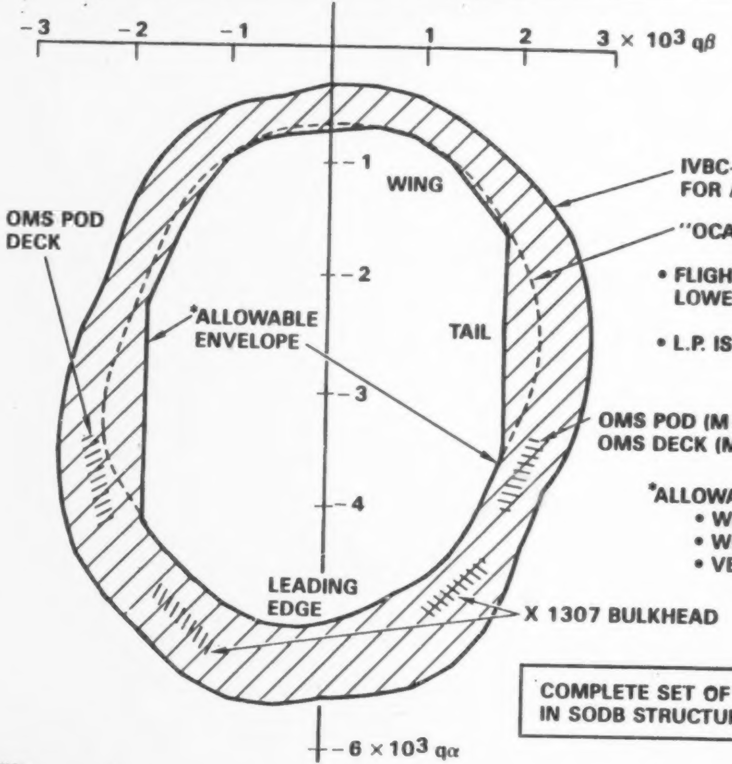
5 MAJOR STRUCTURAL ELEMENTS CANNOT MEET IVBC-3/6.0 LOADS

CONSTRAINTS HAVE BEEN DEFINED:

- WING (STRUTS, UPPER SKIN, X_0 1307 INTERFACE)
- AFT FUSELAGE (X_0 1307 BULKHEAD, OMS DECK, THRUST STRUCTURE LUG SHIMS FOR OV-102/104)
- VERTICAL TAIL (LUGS, SKIN PANELS, RIB, FASTENERS)
- WING LEADING EDGE — 9 PANELS
- OMS PODS (KEEL WEB, LONGERON) .

Example of Ascent Flight Restriction Derived From 6.0 Analysis Results

MACH NO. = 1.25



IVBC-3/6.0 FLIGHT ENVELOPE FOR ASSESSMENT L.P. = 95%

"OCA-D" FLIGHT ENVELOPE

- FLIGHT RESTRICTIONS RESULT IN LOWER LAUNCH PROBABILITY (L.P.)
- L.P. IS MISSION DEPENDENT

OMS POD (M = 1.55)
OMS DECK (M = 1.05)

*ALLOWABLE ENVELOPE DETERMINED BY:
  - WING STRUCTURE
  - WING LEADING EDGE
  - VERTICAL TAIL

X 1307 BULKHEAD

COMPLETE SET OF FLIGHT RESTRICTIONS DEFINED IN SODB STRUCTURAL CONSTRAINTS DOCUMENT

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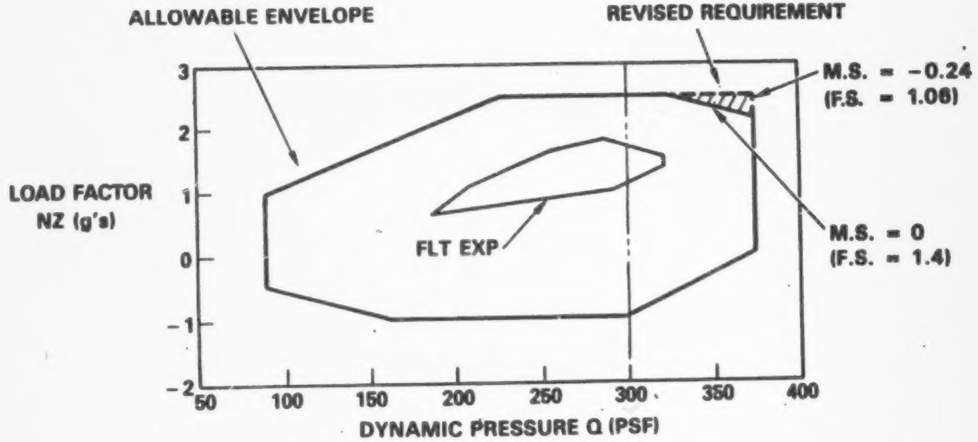
Systems Division

Change to V-n Diagram Clears All Structural Elements to 6.0 Loads

STEADY PITCH V-n DIAGRAM FOR MACH = 0.80

- EXCESSIVE AIRLOADS ON WING LEADING EDGE PANEL & TRUSS TUBES
- NORMAL FLTS PLANNED AT 300 PSF OR LESS



Recommendations

Recommendations for Structural Elements With Negative Margins

- LIVE WITH CONSTRAINTS AS DEFINED
- THE FOLLOWING STRUCTURAL MODIFICATIONS ARE BEING MADE AS PROGRAM REQUIREMENTS DICTATE
  - WING
    - STRUTS
    - X_o 1307 SPAR INTERFACE
    - UPPER COVER STIFFENER

    MODIFICATION PERIOD 3-6 MO
  - OMS/DECK
    - BEEF-UP 2 INNER CAPS
      - INADEQUATE DESIGN

    MODIFICATION PERIOD 3-6 MO
  - THRUST STRUCTURE LUGS (OV-102, OV-104)
    - ADD SHIMS AS REQUIRED
      - TRIVIAL CHANGE

    MODIFICATION PERIOD 1-2 MO
  - OMS PODS
    - BEEF-UP KEEL WEB & LONGERON
      - ALLOWS FOR INCREASED CONSUMMABLES FOR ASCENT/DESCENT

    MODIFICATION PERIOD 2-3 MO

Recommendation for Structural Elements With Negative Margins

- ACCEPT EXISTING CAPABILITY OF THE VERTICAL TAIL ITEMS
  - VERTICAL TAIL
    - NEED FOR ADDITIONAL MISSION PERFORMANCE NOT YET DEFINED
    - LARGE COST & VEHICLE IMPACT TO FIX

Summary

- CONSTRAINTS DEFINED FOR CRITICAL COMPONENTS
    - WINGS, TAILS, AFT FUSELAGE, OMS PODS, WING LEADING EDGE
- DEGRADATION OF LAUNCH PROBABILITY DUE TO CONSTRAINED STRUCTURE IS
    - MISSION DEPENDENT (70-80%)

Summary — Fleet Certification

- MARGINS OF SAFETY DEFINED
- CERTIFIED BOUNDARIES DEFINED
- SOME OV-102 ANALYSIS REMAINS

Acronyms

AOA — ABORT ONCE AROUND
DCR-2 — DESIGN CERTIFICATION REVIEW — LIFT-OFF LOADS-2
DCR-3 — DESIGN CERTIFICATION REVIEW — LIFT-OFF LOADS-3
EOM — END OF MISSION
ET — EXTERNAL TANK
ETR — EASTERN TEST RANGE
IVBC-2 — INTEGRATED VEHICLE BASELINE CHARACTERIZATION 2ND REVISION
IVBC-3 — INTEGRATED VEHICLE BASELINE CHARACTERIZATION 3RD REVISION
5.4 LOADS — ORIGINAL ORBITER LOAD SET
6.0 LOADS — NEW ORBITER LOAD SET
MLG — MAIN LANDING GEAR
NLG — NOSE LANDING GEAR
OCA-D — ORBITAL CAPABILITY ASSESSMENT-D REVISION
OFT — ORBITAL FLIGHT TEST
OMS — ORBITAL MANEUVERING SYSTEM
PLBD — PAYLOAD BAY DOOR
POL — PROBABILITY OF LAUNCH
PSF — POUNDS PER SQUARE FOOT
PSI — POUNDS PER SQUARE INCH
q — DYNAMIC PRESSURE LB/SQ FT
RCS — REACTION CONTROL SYSTEM
RPL — RATED POWER LEVEL
RTLS — RETURN TO LAUNCH SITE
TAL — TRANSATLANTIC ABORT
TPS — THERMAL PROTECTION SYSTEM
WTR — WESTERN TEST RANGE

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38SSV211868A

Orbiter Structural Certification and Flight Operations

February 27, 1989

R.E. Gatto
Director, Structures Analysis
Space Transportation Systems Division

Rockwell
International

Orbiter Structural Certification
and Flight Operations

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Space Transportation
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Objectives

- SUMMARIZE THE RESULTS OF THE ORBITER STRUCTURAL CERTIFICATION (6.0 ANALYSIS), & THE SUBSEQUENT DEFINITION OF ALLOWABLE FLIGHT ENVELOPES
- DESCRIBE ON-GOING WORK TO ENHANCE ALLOWABLE FLIGHT ENVELOPES

Summary

- ALLOWABLE FLIGHT ENVELOPE HAS BEEN DETERMINED FROM ORBITER 6.0 CERTIFICATION ANALYSIS
  - LOAD INDICATORS & REDLINES
  - "GREEN SQUATCHELOIDS"

- ORBITER 102 (COLUMBIA) REQUIRES ADDITIONAL ANALYSIS BECAUSE OF STRUCTURAL DIFFERENCES

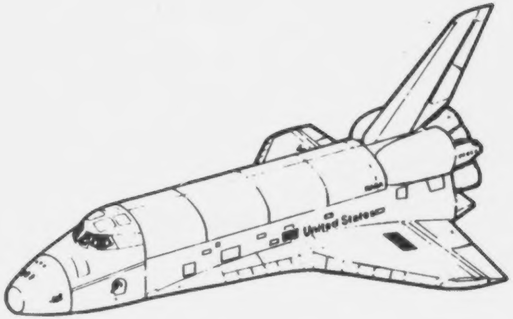
- SHUTTLE PROGRAM HAS TAKEN ACTION TO ENHANCE MISSION FLEXIBILITY
  - TRAJECTORY DESIGN
  - STRUCTURAL LOADS
  - STRUCTURAL HARDWARE
  - DAY-OF-LAUNCH PROCESSES

- ADDITION ON-GOING ACTIONS WILL PROVIDE FURTHER IMPROVEMENT IN MISSION FLEXIBILITY

Allowable Flight Envelope Was Established At Design Certification Review (March 1988)

- ORBITER 6.0 ANALYSIS COMPLETE
- MANDATORY HARDWARE MODIFICATIONS COMPLETE
- ALLOWABLE FLIGHT ENVELOPE DEFINED
  - LOAD INDICATORS & REDLINES
  - "GREEN SQUATCHELOIDS"
- ALLOWABLE FLIGHT ENVELOPE USED FOR:
  - MISSION TRAJECTORY DESIGN
  - DAY OF LAUNCH PROCESSING

Certification Is Derived From 6.0 Analysis



- 4-YEAR EFFORT
- 60,000 PARTS
  - 30,000 STRUCTURAL
  - 30,000 TPS
- F.S. CALCULATION FOR EACH PART
- 110,000-PAGE REPORT
- VERY COMPREHENSIVE

ALLOWABLE FLIGHT CONDITIONS DEVELOPED FROM THOROUGH CERTIFICATION BASE

Shuttle Program Actions Have Been Taken

- OBJECTIVE IS TO ENHANCE MISSION FLEXIBILITY (i.e., "LAUNCH PROBABILITY") WHILE MAINTAINING REQUIRED FACTOR OF SAFETY

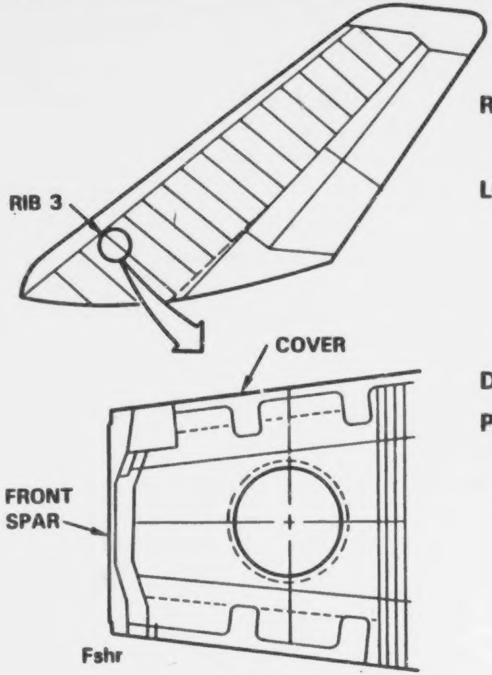
- "LAUNCH PROBABILITY" IS THE STATISTICAL LIKELIHOOD OF NOT ENCOUNTERING A DELAY IN THE LAUNCH DUE TO EXCESSIVE WINDS ALOFT
  - DETERMINED BY ENGINEERING ANALYSIS OF A PARTICULAR MISSION USING A STATISTICAL SEASONAL MODEL OF THE WINDS

Allowable Flight Conditions Are Defined by Load Indicator Equations and Green Squatcheloids

- LOAD INDICATOR EQUATIONS
  - PROVIDES CALCULATION OF STRESS AT CRITICAL STRUCTURAL LOCATIONS
  - WRITTEN IN TERMS OF TRAJECTORY PARAMETERS & APPLIED LOADS
  - "REDLINE VALUE" IS MAXIMUM ALLOWABLE
- GREEN SQUATCHELOIDS
  - ENVELOPE OF ALLOWABLE FLIGHT CONDITIONS, AS DETERMINED IN CERTIFICATION ANALYSIS
  - WRITTEN IN TERMS OF MACH NO., $q\alpha$, $q\beta$

IT IS REQUIRED THAT THE SHUTTLE BE OPERATED WITHIN THE LOAD INDICATOR REDLINES & WITHIN THE GREEN SQUATCHELOIDS, THEREBY FACTOR OF SAFETY ≥ 1.4 IS ASSURED

Orbiter Vertical Tail Load Indicator VT-15
Rib Shear Panel



RIB SHEAR PANEL

REDLINE LIMIT ALLOWABLE:

SHEAR STRESS = 6258 PSI

LOAD INDICATOR EQUATION:

Fshr = Fshr,b + (ABS[(1.074871E−3)Fx
+ (1.065612E−5)Fy + (1.636042E−3)Fz
− (1.301391E−3)Mx − (1.417193E −6)My
− (1.133612E−3)Mz])1.045

MONITOR FOR ASCENT HIGH Q COND

DESIGN COND S.F. = 1.40

PARAMETERS ARE DEFINED AS:

Fshr,b: BUFFET LIMIT

Fx, Fy, Fz, Mx, My, Mz: TAIL ROOT LOADS
SUMMED TO X_o = 1412.126
Y_o = 0
Z_o = 500

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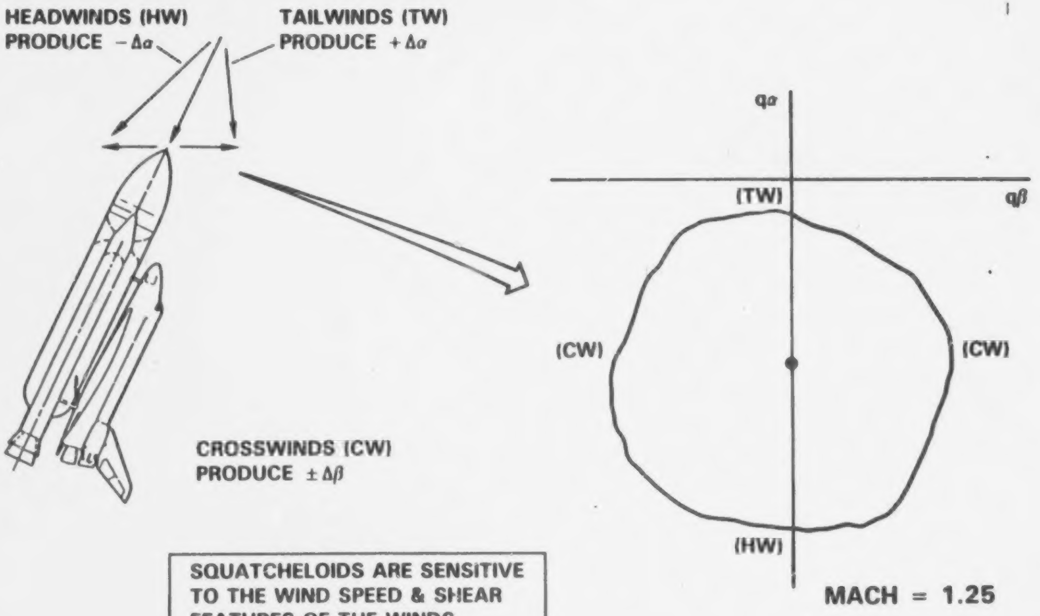
1-34

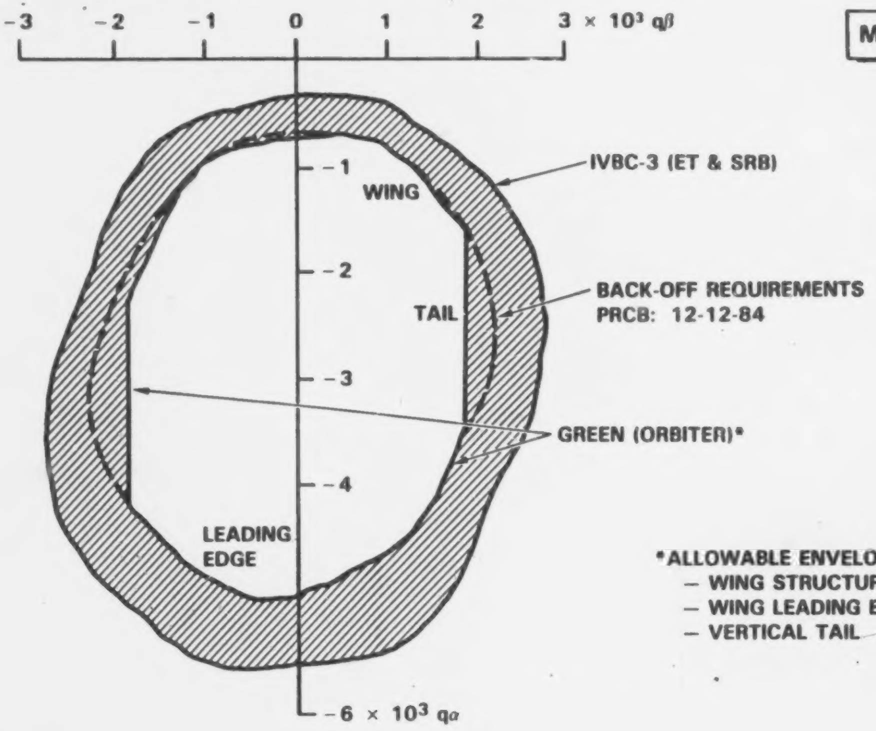
The Squatcheloid Is An Envelope of Trajectory/Wind Conditions


HEADWINDS (HW)
PRODUCE $-\Delta\alpha$
TAILWINDS (TW)
PRODUCE $+\Delta\alpha$
CROSSWINDS (CW)
PRODUCE $\pm\Delta\beta$
$q\alpha$
$q\beta$
(TW)
(CW)
(CW)
(HW)
MACH = 1.25

SQUATCHELOIDS ARE SENSITIVE TO THE WIND SPEED & SHEAR FEATURES OF THE WINDS

Certification Squatcheloids

MACH NO. = 1.25



*ALLOWABLE ENVELOPE DETERMINED BY:
- WING STRUCTURE
- WING LEADING EDGE
- VERTICAL TAIL

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1-11

Actions Have Been Taken to Enhance Mission Flexibility While Maintaining Required Factor of Safety

➡ • TRAJECTORIES

• LOADS

• STRUCTURE

• DAY OF LAUNCH PROCESSES

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Trajectory Design Actions Have Been Taken

- MISSION TRAJECTORIES ARE BEING DESIGNED PER 6.0 ALLOWABLE FLIGHT ENVELOPES (SEE FOLLOWING CHART)
- ALTERNATE TRAJECTORY DESIGNS ARE AVAILABLE FOR SELECTION BASED ON DAY OF LAUNCH MEASURED WINDS
  - STS-26 BASELINE PLUS ONE ALTERNATE AVAILABLE
  - STS-27 BASELINE PLUS TWO ALTERNATES AVAILABLE
  - STS-29 BASELINE PLUS FOUR ALTERNATES AVAILABLE
- UNDER DEVELOPMENT
  - CAPABILITY TO DEFINE ALTERNATE TRAJECTORY BASED ON DAY OF LAUNCH MEASURED WINDS

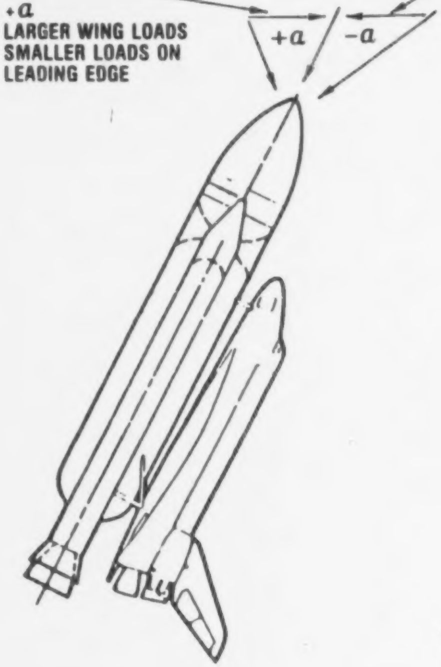
Structural Constraints Are Included in Trajectory Design Process

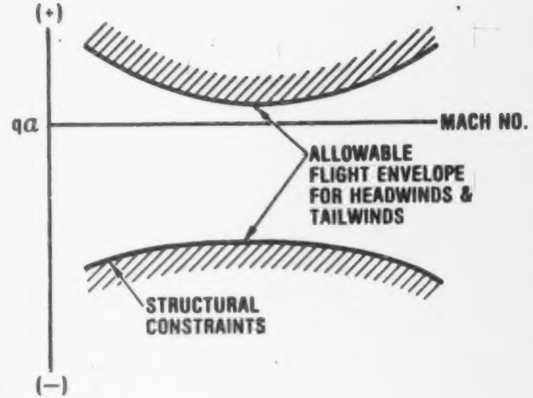
TAILWIND:

- $+\alpha$
- LARGER WING LOADS
- SMALLER LOADS ON LEADING EDGE

HEADWIND:

- $-\alpha$
- SMALLER WING LOADS
- LARGER LOADS ON LEADING EDGE





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Actions Have Been Taken to Enhance Mission Flexibility While Maintaining Required Factor of Safety

- TRAJECTORIES
- ➡ LOADS
- STRUCTURE
- DAY OF LAUNCH PROCESSES

Structural Loads Analysis Actions Have Been Taken

- VERTICAL TAIL LOADS/STRESS ANALYSIS
  - REFINED TREATMENT OF "AEROELASTIC INCREMENT"
  - PROVIDES REDUCTION OF LOADS & EXPANDED "GREEN SQUATCHELOID"
  - ANALYSIS TO BE COMPLETED BY MARCH 17, 1989
  - EARLY RESULTS BEING PREPARED FOR USE ON STS-29
- NEW ANALYTICAL MODEL FOR WIN~~G~~D GUST
  - UNDER DEVELOPMENT BY NASA/MSFC
  - WILL PROVIDE REDUCTION OF LOADS & EXPANDED "GREEN SQUATCHELOID"

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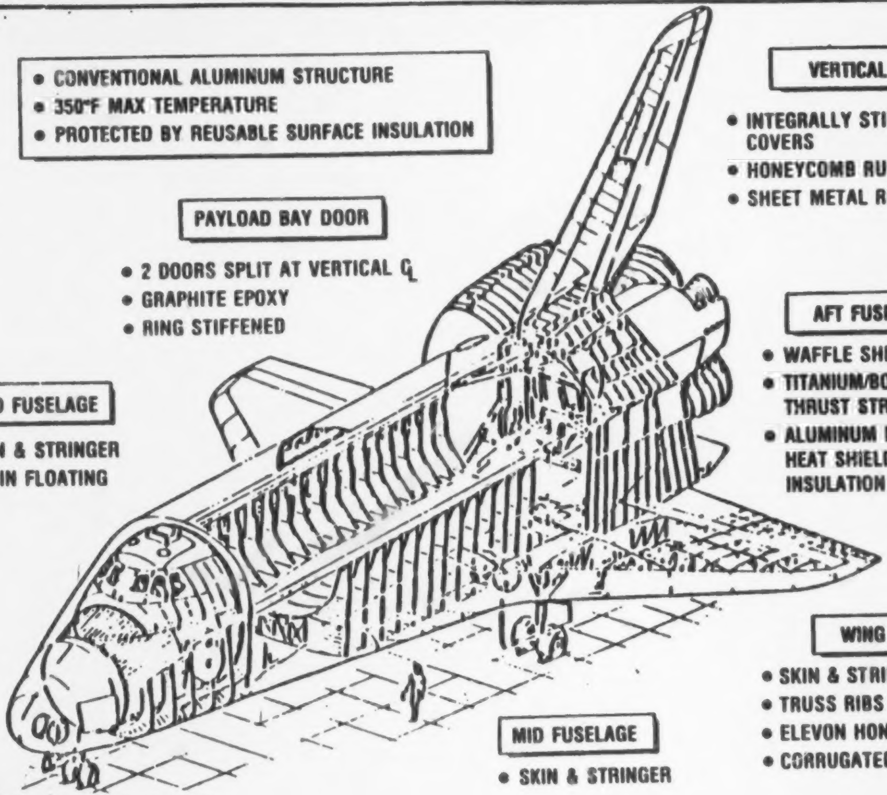
Actions Have Been Taken to Enhance Mission Flexibility While Maintaining Required Factor of Safety

- TRAJECTORIES
- LOADS
- ➡ STRUCTURE
- DAY OF LAUNCH PROCESSES

Orbiter Structure Subsystem



- CONVENTIONAL ALUMINUM STRUCTURE
- 350°F MAX TEMPERATURE
- PROTECTED BY REUSABLE SURFACE INSULATION

PAYLOAD BAY DOOR

- 2 DOORS SPLIT AT VERTICAL ℄
- GRAPHITE EPOXY
- RING STIFFENED

FWD FUSELAGE

- SKIN & STRINGER
- CABIN FLOATING

VERTICAL

- INTEGRALLY STIFFENED FIN COVERS
- HONEYCOMB RUDDER COVER
- SHEET METAL RIBS

AFT FUSELAGE

- WAFFLE SHELL
- TITANIUM/BORON EPOXY THRUST STRUCTURE
- ALUMINUM HONEYCOMB BASE HEAT SHIELD WITH THERMAL INSULATION

WING

- SKIN & STRINGER COVERS
- TRUSS RIBS
- ELEVON HONEYCOMB COVERS
- CORRUGATED SPAR WEBS

MID FUSELAGE

- SKIN & STRINGER

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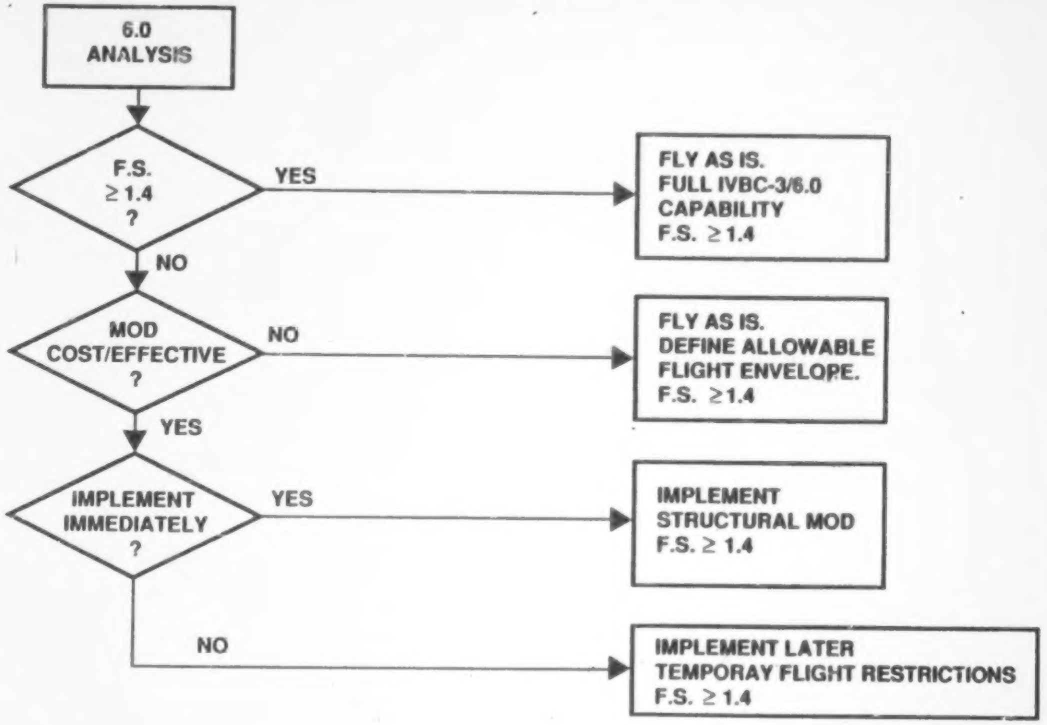
Decisions to Implement Structural Modifications Are Based on Assessments of Cost-Effectiveness in Enhancing Vehicle Performance



6.0
ANALYSIS

F.S.
≥ 1.4
?

YES

FLY AS IS.
FULL IVBC-3/6.0
CAPABILITY
F.S. ≥ 1.4

NO

MOD
COST/EFFECTIVE
?

NO

FLY AS IS.
DEFINE ALLOWABLE
FLIGHT ENVELOPE.
F.S. ≥ 1.4

YES

IMPLEMENT
IMMEDIATELY
?

YES

IMPLEMENT
STRUCTURAL MOD
F.S. ≥ 1.4

NO

IMPLEMENT LATER
TEMPORAY FLIGHT RESTRICTIONS
F.S. ≥ 1.4

Results of 6.0 Analysis Have Been Incorporated Into Orbiter Certification

- MOST OF THE ORBITER IS FULLY CLEARED TO THE IVBC-3/6.0 LOADS
- COMPONENTS NOT CLEARED BY ANALYSIS HAVE BEEN DISPOSITIONED AS FOLLOWS:

Ⓐ
- STRUCTURAL MODIFICATION APPROVED FOR IMMEDIATE IMPLEMENTATION

Ⓑ
- STRUCTURAL MODIFICATION APPROVED FOR LATER IMPLEMENTATION
- TEMPORARY FLIGHT RESTRICTION

Ⓒ
- STRUCTURAL MODIFICATION NOT COST EFFECTIVE
- FLY AS-IS WITHIN DEFINED ALLOWABLE CONDITIONS

Ⓐ Structural Modifications Were Approved For Immediate Implementation

- MID FUSELAGE FRAME STRUTS
- MID FUSELAGE HINGE FITTINGS
- MID FUSELAGE LOWER PANEL HEAT SINK
- THRUST STRUCTURE SHIMS
- OM~~D~~S POD WEB & LONGERON
- EXTERNAL TANK ATTACHMENT PRELOAD

ⒷStructural Modifications Were Approved For Later Implementation

- IMPLEMENTATION IS PLANNED TO OCCUR AT THE REGULAR SCHEDULE MAINTENANCE PERIOD FOR EACH ORBITER
  - WING TRUSS TUBES
  - WING UPPER SKIN PANEL
  - WINGSPAR WEB & JOINT
  - AFT FUSELAGE OMS DECK FRAMES

TEMPORARY RESTRICTIONS ON ALLOWABLE FLIGHT ENVELOPE HAVE BEEN DEFINED TO MAINTAIN FACTOR OF SAFETY

R. E. Gatto
2-24-89

STATUS OF 6.0 STRUCTURAL MODIFICATIONS

FLIGHT EFFECTIVITY

	OV-102	OV-103	OV-104	OV-105
Next Flight	(8)	(8)	(4)	(1)
MID FUSELAGE				
Frame Struts	(8)	C	C	(1)
Hinge Fittings	(8)	C	C	(1)
Radius Blocks	(8)	(9)	(5)	(1)
RTV Heat Sink	(8)	C	C	(1)
Carry through Strut	(8)	(9)	(5)	(1)
AFT FUSELAGE				
OMS Deck Frame Caps	(15)	(15)	(13)	(1)
Thrust Structure Shims	(8)	(9)	C	(1)
WING				
Truss Tubes	A	B	B	(1)
Upper Skin Panel	A	B	B	(1)
Spar Web/Joint	A	B	B	(1)
OMS POD				
Web and Longeron Left	C	(9)	C	(1)
Right	C	C	C	(1)
TPS	(8)	NA	NA	NA

A = TBD Pending Completion of Analysis

B = Cost and Schedule Under Review

C = Complete

NA = Not Applicable

©Allowable Flight Conditions Have Been Defined For Components Where Structural Modification Is Not Cost Effective

OVERHEAD WINDOW – MINOR FLIGHT RESTRICTION OF NO PRACTICAL CONSEQUENCE

VERTICAL TAIL – INITIAL ANALYSIS CONCLUDED STRUCTURAL MODS, NOT COST EFFECTIVE

FOLLOW-UP ANALYSIS (REFINED LOADS DEFINITION) MAY IDENTIFY COST EFFECTIVE STRUCTURAL MODIFICATION

ANALYSIS COMPLETE MARCH 17, 1989

Is There Structural Margin Beyond the Certified Constraints?

- LAUNCH COMMIT BASED ON CERTIFIED LIMITS
- WORK IN PROGRESS TO IDENTIFY & CERTIFY ADDITIONAL MARGINS
  - WING
    - POSSIBLE 5% IMPROVEMENT AFTER AERO VALIDATION
    - TWO FLIGHTS OF INSTRUMENTED OV-102
  - WING LEADING EDGE
    - POSSIBLE 5% AT CRITICAL MACH NUMBERS
    - POSSIBLE >5% AT NONCRITICAL MACH NUMBERS
  - VERTICAL TAIL
    - POSSIBLE 10% AT CRITICAL MACH NUMBERS
    - POSSIBLE >10% AT NONCRITICAL MACH NUMBERS
  - OMS DECK
    - STRUCTURAL MOD INSTALLATION

Actions Have Been Taken to Enhance Mission Flexibility While Maintaining Required Factor of Safety

- TRAJECTORIES
- LOADS
- STRUCTURE
- ➡ DAY OF LAUNCH PROCESSES

LSEAT*Evaluates Structural Loads on the Day-of-Launch

- WINDS MEASURED WITH BALLOONS
- TRAJECTORY SIMULATIONS DEVELOPED USING MEASURED WINDS
- STRUCTURAL LOADS COMPUTED USING TRAJECTORY SIMULATIONS

IF LOAD INDICATOR VALUES WITHIN REDLINES

AND

TRAJECTORY Q-ALPHA/Q-BETA WITHIN SQUATCHELOIDS

THEN

IT IS SAFE TO LAUNCH

*LAUNCH SYSTEM EVALUATION ADVISORY TEAM

Actions Have Been Taken in Day-of-Launch Processes

- DATA HANDLING TIME HAS BEEN REDUCED
  - PERMITS BALLOON DATA AT TWO-HOUR INTERVALS
  - REDUCED EXPOSURE TO CHANGES IN WINDS i.e., "WIND PERSISTENCE" PROTECTION
- DISPERSION IN FLIGHT DYNAMICS PARAMETERS
  - UNDER REVIEW CONSIDERING ACTUAL FLIGHT MEASUREMENTS
- SELECTION OF ALTERNATE TRAJECTORY DESIGNS
  - BASED ON DAY-OF-LAUNCH MEASURED WINDS
- UNDER DEVELOPMENT
  - REVISED MODEL OF WIND GUST
  - DAY-OF-LAUNCH TRAJECTORY DESIGN

GOAL: ENHANCED MISSION FLEXIBILITY & REDUCED LIKELIHOOD OF LAUNCH DELAY DUE TO WINDS

Summary

- ALLOWABLE FLIGHT ENVELOPE HAS BEEN DETERMINED FROM ORBITER 6.0 CERTIFICATION ANALYSIS
    - LOAD INDICATORS & REDLINES
    - "GREEN SQUATCHELOIDS"

- ORBITER 102 (COLUMBIA) REQUIRES ADDITIONAL ANALYSIS BECAUSE OF STRUCTURAL DIFFERENCES

- SHUTTLE PROGRAM HAS TAKEN ACTION TO ENHANCE MISSION FLEXIBILITY
    - TRAJECTORY DESIGN
    - STRUCTURAL LOADS
    - STRUCTURAL HARDWARE
    - DAY-OF-LAUNCH PROCESSES

- ADDITION ON-GOING ACTIONS WILL PROVIDE FURTHER IMPROVEMENT IN MISSION FLEXIBILITY

Orbiter Structural Certification and Flight Operations

February 27, 1989

R.E. Gatto
Director, Structures Analysis
Space Transportation Systems Division

Rockwell
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NSTS ENGINEERING INTEGRATION

Johnson Space Center, Houston, Texas

Presenter R. W. Moorehead

Date 02/27/89

DAY OF LAUNCH STRUCTURAL ASSESSMENT
TO INSURE FLIGHT SAFETY

NSTS ENGINEERING INTEGRATION

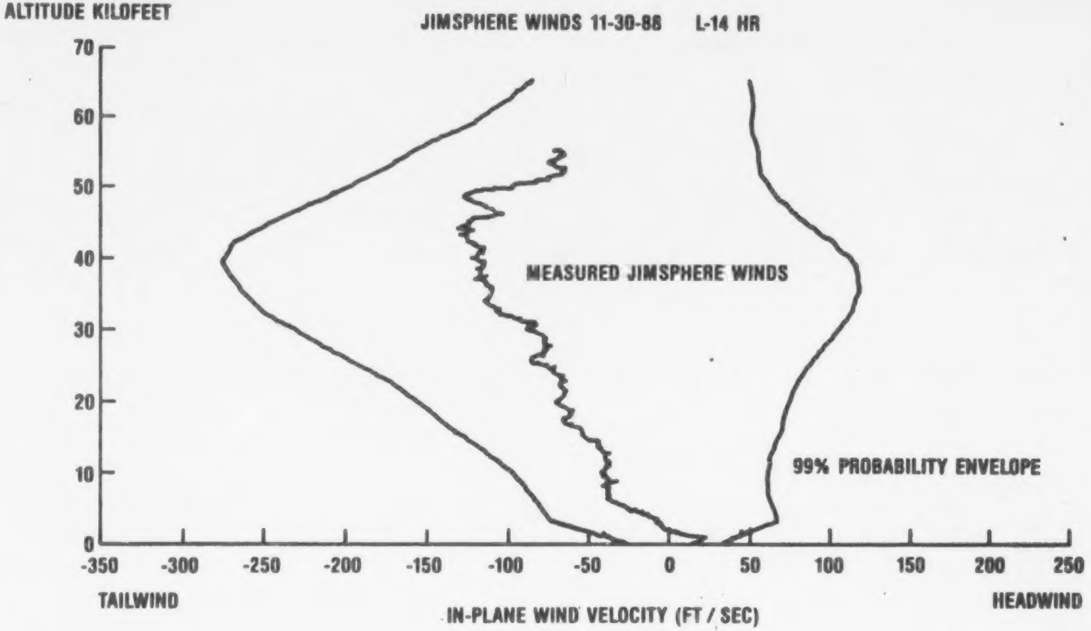
Johnson Space Center, Houston, Texas

A SPECIAL ENGINEERING TEAM EVALUATES STRUCTURAL LOADS ON THE DAY OF LAUNCH

Presenter R. W. Moorehead
Date 02/27/89

- LAUNCH SYSTEM EVALUATION ADVISORY TEAM (LSEAT)
  - REPRESENTATIVES FROM NSTS ENGINEERING, ORBITER, EXTERNAL TANK, SOLID ROCKET BOOSTER, CONTRACTOR AND FLIGHT CREW
- CHARTERED TO MEASURE ATMOSPHERIC WINDS ON THE DAY OF LAUNCH, AND DETERMINE IF THE SHUTTLE STRUCTURE CAN SAFELY FLY THROUGH THOSE WINDS
  - RECOMMENDS GO OR NO GO TO MISSION MANAGEMENT TEAM RESPONSIBLE FOR LAUNCH

Measured Wind Example



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Johnson Space Center, Houston, Texas

STRUCTURAL LIMITS ARE PREVIOUSLY DEFINED BY ELEMENT PROJECTS

Presenter R. W. Moorehead

Date 02/27/89

- ORBITER, EXTERNAL TANK, AND SOLID ROCKET BOOSTER PROJECTS
  - STRESS ANALYSIS FOR PREDICTED MAXIMUM DESIGN LOADS
  - DEFINITION OF STRUCTURAL LIMITS
    - SAFETY FACTOR = 1.4 AT STRUCTURAL LIMIT

NSTS ENGINEERING INTEGRATION

Johnson Space Center, Houston, Texas

STRUCTURAL LIMITS ARE EXPRESSED AS LOADS OR TRAJECTORY FLIGHT CONSTRAINTS

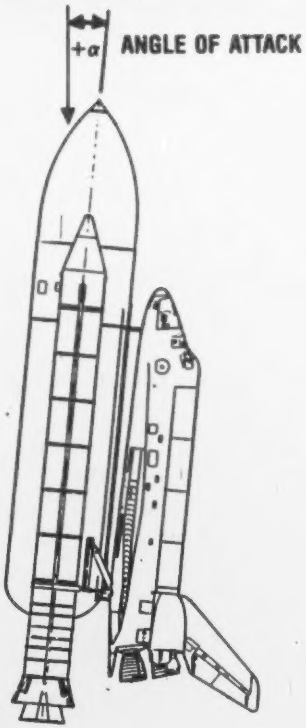
Presenter R. W. Moorehead
Date 02/27/89

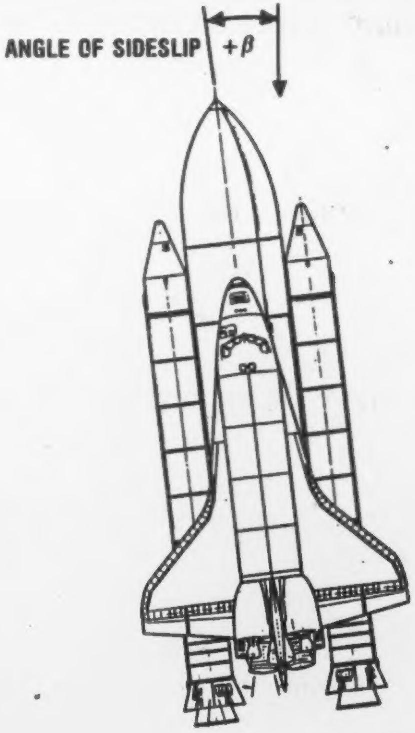
- CRITICAL STRUCTURE IS PROTECTED BY EQUATIONS RELATING LOAD IN A STRUCTURE TO TRAJECTORY PARAMETERS (LOAD INDICATORS)

- STRUCTURAL LIMIT IS EXPRESSED AS EQUATION VALUE NOT TO BE EXCEEDED (REDLINES)

- IN ADDITION, SOME LIMITS ARE EXPRESSED AS CONSTRAINTS ON TRAJECTORY PARAMETERS
  - ANGLE OF ATTACK (α)
  - ANGLE OF SIDESLIP (β)
  - DYNAMIC PRESSURE (q)

Trajectory Parameters


+α
ANGLE OF ATTACK


ANGLE OF SIDESLIP
+β

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COMPUTER SIMULATIONS OF TRAJECTORY AND LOADS PERFORMED ON THE DAY OF LAUNCH

Presenter R. W. Moorehead
Date 02/27/89

- WINDS ALOFT MEASURED BY RADAR TRACKING OF METEROLOGICAL BALLOONS WHICH ASCEND THROUGH ATMOSPHERE

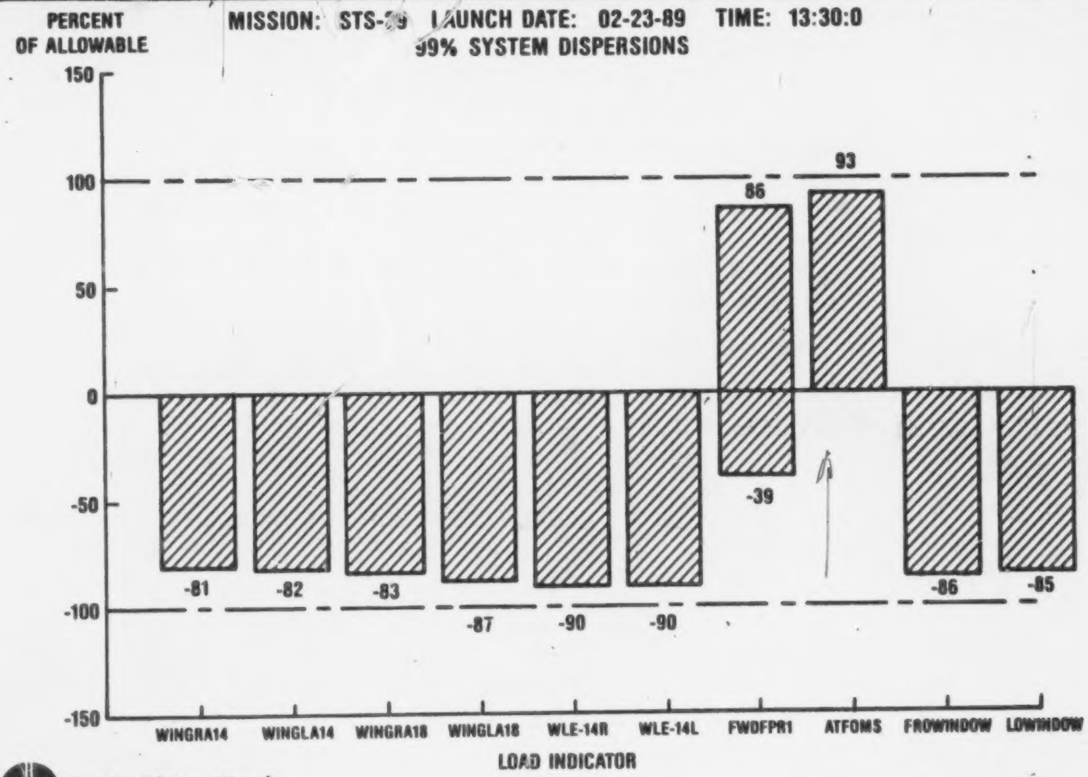
- COMPUTER PROGRAMS PERFORMS SHUTTLE TRAJECTORY SIMULATION USING MEASURED WINDS
  - TRAJECTORY PARAMETERS COMPARED TO LIMITS

- COMPUTER PROGRAMS ALSO DETERMINE SHUTTLE LOADS USING TRAJECTORY SIMULATIONS AND MEASURED WINDS
  - LOAD INDICATOR EQUATIONS EVALUATED AND COMPARED TO REDLINES

- GO RECOMMENDATION MADE TO MISSION MANAGEMENT TEAM IF ALL STRUCTURAL LIMITS ARE SATISFIED

Example of Load Indicator Comparison to Redline Limits

MISSION: STS-29 LAUNCH DATE: 02-23-89 TIME: 13:30:0
99% SYSTEM DISPERSIONS



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Johnson Space Center, Houston, Texas

ALLOWANCES FOR UNKNOWNS CONSIDERED IN DAY OF LAUNCH ASSESSMENT

Presenter R. W. Moorehead

Date 02/27/89

- STRUCTURAL LIMITS REDUCED TO PROTECT FOR:
  - SYSTEM DISPERSION
    - POSSIBLE OFF-NOMINAL PERFORMANCE OF CRITICAL SYSTEMS LIKE THRUST VECTOR CONTROL, INERTIAL MEASUREMENT UNIT, ETC.
  - WIND GUST
    - FLEX BODY VEHICLE RESPONSE TO PREDICTED WORST CASE GUST
    - FLEX BODY RESPONSE IS NOT MODELED IN THE DAY OF LAUNCH LOADS ANALYSIS
  - WIND PERSISTENCE
    - POTENTIAL VARIATION IN WIND MAGNITUDE AND CHARACTER EXPECTED IN 2 HOUR PERIOD BETWEEN LAST BALLOON MEASUREMENT AND LAUNCH

NSTS ENGINEERING INTEGRATION

Johnson Space Center, Houston, Texas

STRUCTURAL LIMITS EVALUATED REPEATEDLY AND INDEPENDENTLY FOR SAFETY	Presenter R. W. Moorehead
	Date 02/27/89

- WINDS MEASURED AND LIMITS EVALUATED AT FREQUENT INTERVALS BEFORE LAUNCH
  - ESTABLISHES WIND TRENDS
  - PROVIDES FOR REASONABLENESS CHECKS
- INDEPENDENT TRAJECTORY AND LOADS SIMULATIONS PERFORMED AT ROCKWELL/DOWNEY USING DIFFERENT COMPUTER PROGRAMS
  - INSURES ACCURATE ASSESSMENT OF STRUCTURAL LIMITS

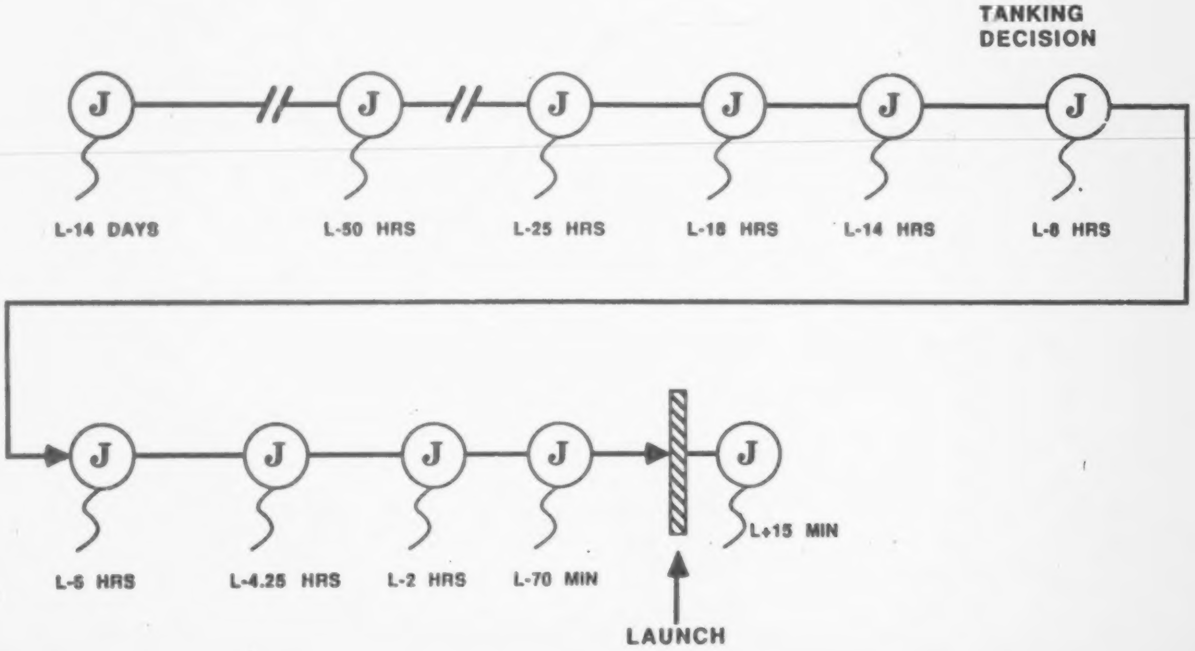
NSTS ENGINEERING INTEGRATION

Johnson Space Center, Houston, Texas

BALLOON RELEASE TIMELINE

Presenter R. W. Moorehead

Date 02/27/89


TANKING DECISION
J
L-14 DAYS
L-50 HRS
L-25 HRS
L-18 HRS
L-14 HRS
L-8 HRS
L-5 HRS
L-4.25 HRS
L-2 HRS
L-70 MIN
L+15 MIN
LAUNCH

Presenter R. W. Moorehead
Date 02/27/89

SUMMARY

- SHUTTLE ELEMENT PROJECTS DEFINE STRUCTURAL LIMITS
- EVALUATION TEAM INSURES STRUCTURAL LIMITS NOT VIOLATED ON DAY OF LAUNCH
  - DOL OF LAUNCH WINDS MEASURED
  - LOADS COMPUTED AND COMPARED TO LIMITS
- PROTECTION IS PROVIDED FOR SYSTEM DISPERSIONS, WIND GUST, AND WIND PRESISTENCE
- INDEPENDENT ASSESSMENTS ARE PERFORMED ON DAY OF LAUNCH TO INSURE ACCURACY IN MAKING GO/NO GO DECISION

NSTS ENGINEERING INTEGRATION

Johnson Space Center, Houston, Texas

Presenter	R. W. Moorehead
Date	02/27/89

ADVANCE SOLID ROCKET MOTOR

(ASRM)

ASRM ENGINEERING INTEGRATION EFFORT

Presenter R. W. Moorehead
Date 02/27/89

- OBJECTIVE
  INCORPORATE ASRM INTO NSTS WITH MINIMAL IMPACT TO SYSTEMS DESIGN CERTIFICATION WHILE INCREASING VEHICLE LIFT CAPABILITY AND SAFETY
- PHASE A/B INTEGRATION ACTIVITIES
  - ASRM DESIGN CRITERIA BASELINED TO INSURE COMPATILITY WITH DCR INDUCED ENVIRONMENTS
    - PRELAUNCH LOADS
    - LIFTOFF LOADS
    - INFLIGHT LOADS
    - HEATING
    - LIFTOFF AND SRB SEPARATION CLEARANCES
    - DYNAMIC STABILITY
  - DEFINED THRUST PROFILE PROVIDES INCREASED PAYLOAD CAPABILITY AND MINIMUM SSME THROTTLE REQUIREMENTS WITHIN IVBC-3 CONSTRAINTS
  - 4 INCH SRM DIAMETER INCREASE PROVIDES INCREASED PAYLOAD CAPABILITY WHILE MAINTAINING AERODYNAMIC DESIGN COMPATIBILTY

NSTS ENGINEERING INTEGRATION

Johnson Space Center, Houston, Texas

Presenter	R. W. Moorehead
Date	02/27/89

ASRM ENGINEERING INTEGRATION EFFORT

- PHASE C/D INTEGRATION ACTIVITY
  - PHASE C/D ACTIVITY TO COMMENCE APRIL 1989
  - VERIFY ASRM DESIGN COMPATIBILTY WITH NSTS ELEMENT CONSTRAINTS
    - PROVIDE ENVIRONMENTS FOR DESIGN
    - DETAILED ANALYSES AS DESIGN MATURES
    - RECOMMEND CHANGES AS REQUIRED
  - PROVIDE COMPARISON OF DCR/ASRM ENVIRONMENTS
  - PRODUCE UPDATED ENVIRONMENTS FOR RECERTIFICATION
    - AS REQUIRED PRIOR TO FIRST FLIGHT

Mr. **Nagle**. Is there any place under conditions that we're currently flying the orbiter—not the motors, the orbiter—under conditions that are what we would call marginally safety—safe?

Mr. **Abbey**. Not at all.

Mr. **Nagle**. Um-hum.

Mr. **Abbey**. I think we're in a situation where we monitor all of those conditions very closely before we launch and we would not launch into those situations, and we haven't launched into those situations.

Mr. **Nagle**. Have those margins been dropped recently? Or reduced? Have conditions been restricted under which we would launch?

Mr. **Abbey**. Well, we have a new load cycle, and that might be, again, what you were speaking about. That load cycle came out about a year ago and we have been reflecting that load cycle back into the constraints for launch.

Mr. **Nagle**. Have there been any studies, reports, analyses or documents that have expressed concern? I want that to be as generic as possible in the scope of my question.

Mr. **Abbey**. I think there have been. There have been reports probably written relative to when you look at the probability of launches and with those constraints that we have to live with, what it does when you look at probability depending on wind conditions during launch. There have been, probably, reports that have expressed concern in that regard.

Mr. **Nagle**. Have there been any reports, analyses or documents submitted to NASA or NASA's own internal review that would indicate to you, or others have expressed concern, over the structural features of the orbiter and the safety and reliance?

Mr. **Abbey**. Those have, the only ones that I'm aware of again have related back to constraints for launch, and there have been reports and comments made relative to that. And again, we don't launch under those conditions and we take those constraints into consideration.

Mr. **Nagle**. Are there any reports, surveys, documents, studies, ongoing at the present time that you anticipate will indicate problems with regard to the structural soundness, in any form, of the orbiter?

Mr. **Abbey**. I think with the exception of the ones I just mentioned, which again relate to launch and launch conditions, I'm unaware of any.

Mr. **Nagle**. Are you aware of any studies that are currently ongoing with regards to the structural soundness of the orbiter itself—not the motors, just the orbiter?

Mr. **Abbey**. Well, we're continually looking at how we're doing.

Mr. **Nagle**. Are there any outside or independent agencies that are doing any?

Mr. **Abbey**. Well, we're continually looking at how we might alleviate and up the probability of that, of launches, so I'm sure that, as we get into work that the contractors are doing, we are doing that. I'm sure there are some efforts going along that line.

Mr. **Nagle**. Dr. Fletcher, do you wish to add anything to that?

Dr. **Fletcher**. I was just going to say that these are not necessarily NASA studies. There's a lot of contractors involved, particularly

Rockwell International, who builds the orbiter. They also have made studies. Some of them come at the problem obliquely and we have—in other words, they have questions about it, and we have to respond to those.

Mr. Nagle. Which groups are raising questions, Dr. Fletcher?

Dr. Fletcher. I don't really recall anything specific, except that I know right after the accident, before I came back to NASA, there was a gentleman that claimed that the upper atmosphere winds were greater than we had been measuring and that we had then, or possibly, a contributory cause to the accident was structural failure of the fastener between the external tank and the orbiter. We did do a thorough analysis of that and we found that was not likely to be the case.

Mr. Nagle. Are there any agencies, independent agencies, quasi-government agencies or government agencies that are currently in the process of doing any studies that have expressed concern over the structural soundness of the orbiter itself?

Dr. Fletcher. Not lately, Mr. Nagle, that I know of. I think George Abbey would know about them if they existed in any formal way.

Mr. Nagle. And there are no currently ongoing studies by any agency, independent agency, government agency or quasi-independent agency that are doing studies as regards the structural soundness of the orbiter itself?

Dr. Fletcher. As I say, I don't really know of any. Now there may be some but we're not aware of them.

Mr. Nagle. Then I don't want to pin you down to, you know, to 2:30 or 3:30 in the afternoon and say, you know, do you know. But could you and I have a little pact here that if upon review with your staff you discover that there are any agencies, independent agencies, quasi-government agencies, or government agencies that are doing these studies that go to the structural soundness of the orbiter that you can't recall right now that you'll tell the committee about them in writing?

Dr. Fletcher. Absolutely, of course, we would do that.

Mr. Nagle. Just want to cover all the bases.

Dr. Fletcher. All right.

[The information follows:]

Currently, NASA is not aware of any agencies, independent agencies, quasi-government agencies or government agencies conducting studies on the structural soundness of the orbiter. NASA has no indication that any internal or external organizations believe that the orbiter is being operated in an unsafe manner.

Mr. Nagle. Okay. Fine.

I thank the chairman for his indulgence. Thank you, Dr. Fletcher. It's been a pleasure working with you.

Mr. Nelson. In case you all haven't met Congressman David Nagle——[Laughter.]

Whenever we want to get answers, we let him out of his cage. [Laughter.]

And it was in great part his persistence, last year, that brought us to the resolution where we needed to be on the CDSF, and we appreciate his participation and his expertise.

Can you list for us, Dr. Fletcher, the priority of all of these ground facilities that you have requested? You got some——

Dr. **Fletcher**. We'd have to supply that for the—you are talking about the privately financed ones, or all of the ground facilities?

Mr. **Nelson**. No. The ones you have in the budget having to do with the Space Station Processing Facility, Neutral Buoyancy Facility, and so forth.

Dr. **Fletcher**. I think we've only mentioned 2 that are privately financed. I can't think of any reason why one should have priority over the other, but they're both in line and necessary for the Space Station.

Mr. **Campbell**. We think we can acquire both by January, Mr. Chairman, in order to meet the station schedule. I believe that's correct.

Mr. **Nelson**. Last July, you gave our committee staff a briefing at the Johnson Space Center in which we got the impression that the Neutral Buoyancy Facility was way down the list on your priorities, and you've got it right up there at the top now, and I'd like to know what has changed in the interim?

Dr. **Fletcher**. Mr. Chairman, that's a pretty astute observation. It was lower priority. I wouldn't say at the bottom of the list, but it was lower priority last year. And there was some convincing that had to be done; it sounded like a glorified swimming pool when we first had it. And they had to go back and do their homework, just like you're asking us to do ours. And we were convinced that if you wanted to have smooth operations on the Space Station you needed a practice facility which included, essentially, the major part of the Space Station, which then required a fairly sizable Neutral Buoyancy Facility.

And you're quite right, we did change our mind on the priority of that facility. And it wasn't because of whether it's privately financed or not. That decision was made long before we came up with the private financing idea.

Mr. **Nelson**. Well, now you have such a facility, a fairly large facility, at Marshall Space Flight Center. Why do you need another large—you, certainly you have a smaller one that's at Johnson. Why do you need this one?

Mr. **Myers**. Mr. Chairman, we have—and, incidentally, I was part of the review team that reviewed that facility. We really did have a problem with whether we needed it, because we had the small facility at Johnson, a larger one at Marshall. But after we went through the process of what a tremendous advantage we'd get for developing the full assembly of the Space Station one place we were convinced that that was a very high priority facility.

And it does take a lot of square footage to be able to put these things, these pieces in as we bring them into space, assemble them. It is not just as simple as plugging them together because, as you remember, many of these roll-outs of utility lines and a significant amount of EVA, and we in our desire to reduce EVA felt that it was necessary to have a facility of this size.

Fact is that the facility this size seems to be one of the things that is beginning to attract private interest in the facility.

Mr. **Nelson**. And the one in Marshall is not of sufficient size?

Mr. **Myers**. It's not nearly large enough to do assembly activity.

Mr. **Nelson**. Would you give us copies of the studies that changed your mind?

Mr. **Myers**. Yes. We'd be pleased to do that.

Mr. **Nelson**. Okay. And we would like the copies of the studies on termination liability that you're talking about as well.

Dr. **Fletcher**. I think we've done that with your staff, but we'll supply it for the record.

Mr. **Nelson**. Okay. We do not have those copies. You say that it's already been done.

Dr. **Fletcher**. Discussed it. We discussed it with the staff.

Mr. **Campbell**. Yes. We briefed your staff on a summary—in a summary level and we will give the, provide the details——

Mr. **Nelson**. We would like that.

[The information follows:]

Material requested for the record on page 93, line 2243, by Chrm. Nelson during the February 2, 1989, hearing at which Dr. Fletcher testified.

Attached are copies of the studies on termination liability and the Neutral Buoyancy Laboratory.

PRIVATIZATION INITIATIVES FOR PROVIDING NASA FACILITIES

OBJECTIVE

TO EXPLORE ARRANGEMENTS TO OBTAIN PRIVATE SECTOR PARTICIPATION (INCLUDING FINANCING) IN FACILITIES FOR NASA'S USE THAT HAVE THE POTENTIAL FOR ECONOMIC BENEFITS, AND THAT MEET NASA'S REQUIREMENTS FOR OPERATIONS, SECURITY AND SAFETY

NASA'S PRIVATIZATION APPROACH

- AGREEMENT BETWEEN NASA AND A PROPOSER TO CONSTRUCT A FACILITY ON OR NEAR (IF APPROPRIATE) NASA PROPERTY FOR LONG-TERM USE BY NASA
  - OFFEROR WILL PROPOSE ALL TERMS AND CONDITIONS OF FINANCING AND TERMINATION LIABILITY SCHEDULE
  - THE PROPOSER COULD PROPOSE TO RETAIN 20% OR MORE OWNERSHIP FOR COMMERCIAL OR JOINT USE, AT THE PROPOSER'S OPTION
  - AGREEMENT WILL CONTAIN NEGOTIATED PROVISIONS FOR FACILITIES DISPOSITION AT THE EXPIRATION OF PLANNED GOVERNMENT USE
    - BUY-OUT OPTION OF PROPOSER'S EQUITY AT END OF USE AGREEMENT MAY BE CONSIDERED
  - NASA GUARANTEES TO MAKE USE PAYMENTS FOR TERM OF AGREEMENT OR PAY TERMINATION CHARGES ACCORDING TO SCHEDULE PROPOSED BY THE OFFEROR
  - EXCEPT FOR SPACE STATION PROCESSING FACILITY, OFFEROR MAY PROPOSE A NEARBY OFF-SITE LOCATION FOR NASA TO EVALUATE FOR MISSION SUITABILITY
    - ON-SITE LOCTION WILL BE BASELINE

PRIVATIZATION PROJECTS
ECONOMIC BENEFITS

ECONOMIC ANALYSIS OF CANDIDATE PRIVATIZATION PROJECTS SHOWS THAT PRIVATIZATION COULD BE BENEFICIAL TO THE GOVERNMENT

PRIVATIZATION ALSO PRECLUDES LARGE OUTLAYS BY THE GOVERNMENT IN FY 90 AND FY 91

STATUS

LOCATION	PROJECT	STATUS
VAR	ASRM PROD & TEST FACILITIES	SEB IN PROGRESS - RECOMMENDATION 4/89
KSC	CONST SPACE STATION PROC FAC	CBD NOTICE ISSUED 12/22/88 50 INQUIRIES RECEIVED REPLIES DUE 2/2/89
JSC	CONST NEUTRAL BUOYANCY LAB	CBD NOTICE ISSUED 11/22/88 25 INQUIRES RECEIVED REPLIES DUE 2/1/89
JPL	CONST OBSERVATIONAL INST. LAB	AWAITING RESULTS FROM OTHER TWO PROJECTS

FACILITIES CAPITAL COST CASH FLOW
(DOLLARS IN MILLIONS)

	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07
KSC-SPACE STATION PROCESSING FACILITY -- COST/YEAR																		
COF	43	41																
PRIVATIZATION	0	0	2.8	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	8.4
JPL-OBSERVATIONAL INSTRUMENTS LAB-- COST/YEAR																		
COF	14	0																
PRIVATIZATION	0	0.4	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.3	0
JSC-NEUTRAL BUOYANCY LAB -- COST/YEAR																		
COF	30	0																
PRIVATIZATION	0	0.9	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	2.8	0

ECONOMIC COMPARISONS - PRESENT VALUE IN JAN 89
(FINANCIER RETAINS 20% OF ASSET)

(DOLLARS IN MILLIONS)

KSC - SPACE STATION PROCESSING FACILITY	TOTAL	PV
COF	84	74
PRIVATIZATION	168	69.5
PRIVATIZATION BENEFITS		4.5

JPL - OBSERVATIONAL INSTRUMENTS LAB	TOTAL	PV
COF	14.0	12.8
PRIVATIZATION	25.1	11.5
PRIVATIZATION BENEFITS		1.3

JSC - NEUTRAL BUOYANCY LAB	TOTAL	PV
COF	30.0	27.5
PRIVATIZATION	54.6	25.1
PRIVATIZATION BENEFITS		2.4

VAR - ASRM PRODUCTION AND TEST FACILITIES

- TO BE DETERMINED: UNDER REVIEW BY SEB --

STANDARDIZED FINANCIAL PARAMETERS FOR ANALYSES

AMORITIZATION PERIOD	15	YEARS
DISCOUNT RATE TO BE USED	9.3%	
INFLATION RATE TO BE USED	4.5%	
SHORT TERM CONSTRUCTION LOAN RATE	12.5%	
LONG TERM AMORTIZATION RATE	10.5%	
PRESENT VALUE CALCULATED TO 1 JANUARY 1989		
BREAK-EVEN CALCULATED FROM STARTING POINT OF FIRST AMORT PAYMENT		

NASA PRIVATIZATION PROJECTS

SUPPORTING FINANCIAL DATA

JANUARY 31, 1989

I N D E X

PAGE 1 SUMMARY OF CASH FLOW & ECONOMIC COMPARISONS
PAGES 2 - 6 KSC SSPF 80/20 OPTION
PAGES 7 - 11 KSC SSPF 100 % OPTION
PAGES 12 - 16 JPL OIL 80/20 OPTION
PAGES 17 - 21 JPL OIL 100 % OPTION
PAGES 22 - 26 JSC NBL 80/20 OPTION
PAGES 27 - 31 JSC NBL 100 % OPTION

01-FEB-89
02:09:31 PM

HOCCSUM

FACILITIES CAPITAL COST CASH FLOW
(DOLLARS IN MILLIONS)

	FY90	FY91	FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07
KSC-SSPF--COST/YR																		
COFF	43.0	41.0	0.0															
PRIVATIZATION	0.0	0.0	2.8	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	8.4
JPL-OIL																		
COFF	14.0	0.0																
PRIVATIZATION	0.0	0.4	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.2	0.0
JSC-NBL																		
COFF	30.0	0.0																
PRIVATIZATION	0.0	0.9	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.5	2.7	0.0

ECONOMIC COMPARISON - PRESENT VALUE IN JAN 89
(FINANCIER RETAINS 20% OF ASET)

(DOLLARS IN MILLIONS)

KSC - SPACE STATION PROCESSING FACILITY	TOTAL	PV
	-----	--
COF	84	73.7
PRIVATIZATION	169	69.9
PRIVATIZATION BENEFITS		3.8
JPL - OBSERVATIONAL INSTRUMENTS LAB	**TOTAL**	**PV**
	-----	--
COF	14	12.8
PRIVATIZATION	24.9	11.3
PRIVATIZATION BENEFITS		1.5
JSC - NEUTRAL BUOYANCY LAB	**TOTAL**	**PV**
	-----	--
COF	30	27.5
PRIVATIZATION	53.8	24.4
PRIVATIZATION BENEFITS		3.1

VAR - ASRM PRODUCTION AND TEST FACILITIES -
TO BE DETERMINED : UNDER REVIEW BY SEB----

KENNEDY SPACE CENTER

SPACE STATION PROCESSING FACILITY

20 % FINANCIER-OWNED

80 % GOVERNMENT-OWNED

JANUARY 31, 1989

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SSPFBL28       CENTER : KSC                          FACILITY :    SPACE STATION PROCESSING FACILITY                                            P.     1
01:33 PM       $$MILLIONS                           C OF F CONSTRUCTION VS. 3RD PARTY FINANCING OF FACILITIES
02/01/89                                                            BASELINE + 3RD FLOOR
                                                           GOVERNMENT OWNS 80% OF FACILITY=$67.2M
                                                   FINANCIER RETAINS 20% OF ASSET VALUE ($16.8M)   TOTAL ASSET VALUE = $84M
PROJECT YEAR #                      0       1       2       3       4       5       6       7       8       9      10      11      12      13      14      15
FISCAL YEAR                      1989    1990    1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004

<<<C OF F CASE>>>
NEW BUILDING COST                0.00   41.15   37.54    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
BUILDING MAINTENANCE             0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
OTHER COSTS--UTIL ON SITE        0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
RESIDUAL VALUE                   0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
          TOTAL                  0.00   41.15   37.54    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
          TOTAL W/INFLATION      0.00   43.00   41.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00

<<<3RD PARTY FINANCING CASE>>>
OTHER COSTS #1--INSURANCE        0.00    0.00    0.00    0.04    0.16    0.16    0.16    0.16    0.16    0.16    0.16    0.16    0.16    0.16    0.16    0.16
OTHER COSTS #2--UTIL ON SIT      0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
OTHER REVENUE--LAND LEASE        0.00    0.00    0.00    0.03    0.11    0.11    0.11    0.11    0.11    0.11    0.11    0.11    0.11    0.11    0.11    0.11
BUILDING MAINTENANCE             0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
YEARLY PAYMENT                   0.00    0.00    0.00    2.80   11.20   11.20   11.20   11.20   11.20   11.20   11.20   11.20   11.20   11.20   11.20   11.20
RESIDUAL VALUE                   0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
          TOTAL                  0.00    0.00    0.00    2.81   11.25   11.25   11.25   11.25   11.25   11.25   11.25   11.25   11.25   11.25   11.25   11.25
          TOTAL W/INFLATION      0.00    0.00    0.00    2.82   11.26   11.27   11.27   11.27   11.28   11.28   11.28   11.29   11.29   11.29   11.30   11.30

PROGRAM COSTS -- ALTERNATE #1 (COFF)  0.00   43.00   41.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
PROGRAM COSTS -- ALTERNATE #2 (3P)    0.00    0.00    0.00    2.82   11.26   11.27   11.27   11.27   11.28   11.28   11.28   11.29   11.29   11.29   11.30   11.30
          PTL -- ALTERNATE #2 (3P)                   82.56   82.56   81.93   79.37   76.54   73.41   69.95   66.13   61.91   57.24   52.09   46.39   40.10   33.14

   NET PRESENT VALUE OF ALTERNATIVES
NPV COFF -- OMB DISCOUNT RATE    0.00   39.34   73.66   73.66   73.66   73.66   73.66   73.66   73.66   73.66   73.66   73.66   73.66   73.66   73.66   73.66
NPV 3RDP -- OMB DISCOUNT RATE    0.00    0.00    0.00    2.16   10.05   17.27   23.88   29.93   35.46   40.53   45.17   49.41   53.29   56.85   60.10   63.08

NPV COFF -- GAO DISCOUNT RATE    0.00   39.41   73.86   73.86   73.86   73.86   73.86   73.86   73.86   73.86   73.86   73.86   73.86   73.86   73.86   73.86
NPV 3RDP -- GAO DISCOUNT RATE    0.00    0.00    0.00    2.17   10.12   17.41   24.09   30.22   35.83   40.98   45.71   50.04   54.01   57.65   60.98   64.05
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```
  16     17     18
2005   2006   2007


 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00


 0.16   0.16   0.12
 0.00   0.00   0.00
 0.11   0.11   0.08
 0.00   0.00   0.00
11.20  11.20   8.40
 0.00   0.00   0.00
11.25  11.25   8.44
11.31  11.31   8.49

 0.00   0.00   0.00
11.31  11.31   8.49
25.46  16.96   7.58


73.66  73.66  73.66
65.81  68.30  70.01

73.86  73.86  73.86
66.85  69.43  71.20
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SSPFBL28                                              SPACE STATION PROCESSING FACILITY
02/01/89 01:33 PM                                           80 % GOVERNMENT OWNED
                                                                     OMB
                                                                                                              P.      3
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################ INPUTS #################
PRIME RATE @12/01/88                =     10.5%
START YEAR 3RD PARTY                =     1990
START MONTH (1.2, ETC) 3RD PARTY    =        1
CONSTRUCTION DURATIN (MO) 3RD PARTY=        30
POPULATION  (1994 ON OUT)           =        0
LEASE PAYMENT ($/SQFT/YR)           =     0.00
LEASE MTC. ($/SQFT/YR)              =     0.00
LEASE SQFT/PERSON                   =     0.00
LEASE INEFFICIENCIES ($M/YR)        =     0.00
BUILDING COST ($M)                  =    84.00
GVMT SHARE OF BUILDING COST ($M)    =    67.20
BUILDING MTC. ($/SQFT/YR)           =     0.00
BUILDING SIZE (K SQFT)              =   398.00
DISCOUNT RATE      (OMB)            =      9.3%
TERM (YRS)                          =       15
INFLATION                           =      4.5%
RESIDUAL VALUE (TODAY'S $M)         =       10
RATE OF INTEREST DURING CONST.      =     12.5%
START YEAR CoFF CONSTRUCTION        =     1990
START MONTH CoFF                    =        1
CONSTRUCTION DURATION (MO) CoFF     =       30
TRAILER REPLACEMENT ($M EA. 10YR)   =        0
START YEAR OF ANALYSIS              =     1989
RATE OF INTEREST LONG-TERM LOAN     =     10.5%
TRAILER MAINTENANCE ($/SQFT)        =     0.00
TRAILER UTILITIES ($/SQFT)          =     0.00
BLDG ON-SITE UTILITIES ($/SQFT)     =     0.00
BLDG OFF-SITE UTILITIES ($/SQFT)    =     0.00
PRIVATE INSURANCE ($/SQFT)          =     0.41
REVENUE FR GVMT LAND LEASE (M$/YR)  =     0.11
FEE (%)                             =      0.0%
METHOD                              = OMB
#########################################
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############################################## OUTPUTS ##############################################
        CUM NASA OUTLAYS, MILLIONS OF CURRENT DOLLARS               NASA OUTLAYS $M (DISCOUNTED)
                            CoFF   3RDPARTY                             CoFF   3RDPARTY
                            0.00     0.00               FY89            0.00     0.00
                           43.00     0.00  3P           FY90           39.41     0.00  3P
                           84.00     0.00  3P           FY91           73.86     0.00  3P
                           84.00     2.82  3P           FY92           73.86     2.17  3P
                           84.00    14.08  3P           FY93           73.86    10.12  3P
                           84.00    25.34  3P           FY94           73.86    17.41  3P
                           84.00    36.61  3P           FY95           73.86    24.09  3P
                           84.00    47.89  3P           FY96           73.86    30.22  3P
                           84.00    59.16  3P           FY97           73.86    35.83  3P
                           84.00    70.44  3P           FY98           73.86    40.98  3P
                           84.00    81.72  3P           FY99           73.86    45.71  3P
                           84.00    93.01  C OF F       FY00           73.86    50.04  3P
                           84.00   104.30  C OF F       FY01           73.86    54.01  3P
                           84.00   115.59  C OF F       FY02           73.86    57.65  3P
                           84.00   126.89  C OF F       FY03           73.86    60.98  3P
                           84.00   138.20  C OF F       FY04           73.86    64.05  3P
                           84.00   149.50  C OF F       FY05           73.86    66.85  3P
                           84.00   160.82  C OF F       FY06           73.86    69.43  3P
----> 15 YEARS AMORTIZATION  84.00   169.30  C OF F       FY07           73.86    71.20  3P



#####################################################################################################
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                                                                                     P.    4
                                                                            SSPFBL2
                                   SUMMARY RESULTS                          02/01/89 01:25 PM

                           SPACE STATION PROCESSING FACILITY

                                 3RD PARTY           3RD PARTY
                                 ACTUAL              NPV
                                 DOLLARS             DOLLARS
                                 ---------           ---------

100 % GOVERNMENT OWNED-OMB        211.30               87.39

100 % GOVERNMENT OWNED-GAO        211.30               88.87

 80 % GOVERNMENT OWNED-OMB        169.04               69.91

 80 % GOVERNMENT OWNED-GAO        169.04               71.09


COF ACTUAL DOLLARS   84.00 M

COF NPV-OMB          73.66 M

COF NPV-GAO          73.86 M

NOTES:  NPV DISCOUNTED BACK TO JAN 1. 1989
        DESIGN COMPLETION FOR CASE 2(INCLUDES 3RD FLOOR) IS OCT 1. 1989
        OMB DISCOUNT RATE = 9.3 %   AND GAO DISCOUNT RATE = 9.1 %
```

KENNEDY SPACE CENTER

SPACE STATION PROCESSING FACILITY

100 % GOVERNMENT-OWNED

JANUARY 31, 1989

SSPFBL2
01:25 PM
02/01/89

CENTER : KSC
$$MILLIONS

FACILITY :   SPACE STATION PROCESSING FACILITY
C OF F CONSTRUCTION VS. 3RD PARTY FINANCING OF FACILITIES
BASELINE + 3RD FLOOR
GOVERNMENT OWNS 100% OF FACILITY=$84M

P. 1

PROJECT YEAR #	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FISCAL YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
<<<C OF F CASE>>>																
NEW BUILDING COST	0.00	41.15	37.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BUILDING MAINTENANCE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER COSTS--UTIL ON SITE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESIDUAL VALUE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	0.00	41.15	37.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL W/INFLATION	0.00	43.00	41.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<<<3RD PARTY FINANCING CASE>>>																
OTHER COSTS #1--INSURANCE	0.00	0.00	0.00	0.04	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
OTHER COSTS #2--UTIL ON SIT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER REVENUE--LAND LEASE	0.00	0.00	0.00	0.03	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
BUILDING MAINTENANCE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
YEARLY PAYMENT	0.00	0.00	0.00	3.50	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
RESIDUAL VALUE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	0.00	0.00	0.00	3.51	14.05	14.05	14.05	14.05	14.05	14.05	14.05	14.05	14.05	14.05	14.05	14.05
TOTAL W/INFLATION	0.00	0.00	0.00	3.52	14.06	14.07	14.07	14.07	14.08	14.08	14.08	14.09	14.09	14.09	14.10	14.10
PROGRAM COSTS -- ALTERNATE #1 (CofF)	0.00	43.00	41.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PROGRAM COSTS -- ALTERNATE #2 (3P)	0.00	0.00	0.00	3.52	14.06	14.07	14.07	14.07	14.08	14.08	14.08	14.09	14.09	14.09	14.10	14.10
PTL -- ALTERNATE #2 (3P)			103.20	103.20	102.41	99.21	95.67	91.76	87.44	82.66	77.38	71.55	65.11	57.99	50.12	41.43
NET PRESENT VALUE OF ALTERNATIVES																
NPV CofF -- OMB DISCOUNT RATE	0.00	39.34	73.66	73.66	73.66	73.66	73.66	73.66	73.66	73.66	73.66	73.66	73.66	73.66	73.66	73.66
NPV 3RDP -- OMB DISCOUNT RATE	0.00	0.00	0.00	2.69	12.55	21.56	29.82	37.37	44.28	50.60	56.39	61.68	66.53	70.97	75.03	78.74
NPV CofF -- GAO DISCOUNT RATE	0.00	39.41	73.86	73.86	73.86	73.86	73.86	73.86	73.86	73.86	73.86	73.86	73.86	73.86	73.86	73.86
NPV 3RDP -- GAO DISCOUNT RATE	0.00	0.00	0.00	2.71	12.63	21.73	30.08	37.73	44.74	51.17	57.06	62.47	67.42	71.96	76.13	79.95

```
SPACE STATION PROCESSING FACILITY                                                                P.   2

                                                                                                 SSPFBL2

    16     17     18
  2005   2006   2007


  0.00   0.00   0.00
  0.00   0.00   0.00
  0.00   0.00   0.00
  0.00   0.00   0.00
  0.00   0.00   0.00
  0.00   0.00   0.00


  0.16   0.16   0.12
  0.00   0.00   0.00
  0.11   0.11   0.08
  0.00   0.00   0.00
 14.00  14.00  10.50
  0.00   0.00   0.00
 14.05  14.05  10.54
 14.11  14.11  10.59

  0.00   0.00   0.00
 14.11  14.11  10.59
 31.82  21.20   9.47


 73.66  73.66  73.66
 82.14  85.26  87.39

 73.86  73.86  73.86
 83.45  86.66  88.87
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SSPFBL2                                                       SPACE STATION PROCESSING FACILITY
02/01/89 01:25 PM                                                  100% GOVERNMENT OWNED
                                                                           OMB
**************** INPUTS *****************   ************************************************** OUTPUTS ***********************************************       P.    3
PRIME RATE @12/01/88               =    10.5%      CUM NASA OUTLAYS, MILLIONS OF CURRENT DOLLARS                  NASA OUTLAYS $M (DISCOUNTED)
START YEAR 3RD PARTY               =    1990                          CoFF  3RDPARTY                                       CoFF  3RDPARTY
START MONTH (1,2, ETC) 3RD PARTY   =       1                          0.00    0.00           FY89                          0.00    0.00
CONSTRUCTION DURATIN (MO) 3RD PARTY=      30                         43.00    0.00  3P       FY90                         39.41    0.00  3P
POPULATION  (1994 ON OUT)          =       0                         84.00    0.00  3P       FY91                         73.86    0.00  3P
LEASE PAYMENT ($/SQFT/YR)          =    0.00                         84.00    3.52  3P       FY92                         73.86    2.71  3P
LEASE MTC. ($/SQFT/YR)             =    0.00                         84.00   17.58  3P       FY93                         73.86   12.63  3P
LEASE SQFT/PERSON                  =    0.00                         84.00   31.64  3P       FY94                         73.86   21.73  3P
LEASE INEFFICIENCIES ($M/YR)       =    0.00                         84.00   45.71  3P       FY95                         73.86   30.08  3P
BUILDING COST ($M)                 =   84.00                         84.00   59.79  3P       FY96                         73.86   37.73  3P
GVMT SHARE OF BUILDING COST ($M)   =   84.00                         84.00   73.86  3P       FY97                         73.86   44.74  3P
BUILDING MTC. ($/SQFT/YR)          =    0.00                         84.00   87.94  C OF F   FY98                         73.86   51.17  3P
BUILDING SIZE (K SQFT)             =  398.00                         84.00  102.02  C OF F   FY99                         73.86   57.06  3P
DISCOUNT RATE      (OMB)           =    9.3%                         84.00  116.11  C OF F   FY00                         73.86   62.47  3P
TERM (YRS)                         =      15                         84.00  130.20  C OF F   FY01                         73.86   67.42  3P
INFLATION                          =    4.5%                         84.00  144.29  C OF F   FY02                         73.86   71.96  3P
RESIDUAL VALUE (TODAY'S $M)        =      10                         84.00  158.39  C OF F   FY03                         73.86   76.13  C OF F
RATE OF INTEREST DURING CONST.     =   12.5%                         84.00  172.50  C OF F   FY04                         73.86   79.95  C OF F
START YEAR CoFF CONSTRUCTION       =    1990                         84.00  186.60  C OF F   FY05                         73.86   83.45  C OF F
START MONTH CoFF                   =       1                         84.00  200.72  C OF F   FY06                         73.86   86.66  C OF F
CONSTRUCTION DURATION (MO) CoFF    =      30   ----> 15 YEARS AMORTIZATION   84.00  211.30  C OF F   FY07                         73.86   88.87  C OF F
TRAILER REPLACEMENT ($M EA. 10YR)  =       0
START YEAR OF ANALYSIS             =    1989
RATE OF INTEREST LONG-TERM LOAN    =   10.5%
TRAILER MAINTENANCE ($/SQFT)       =    0.00
TRAILER UTILITIES ($/SQFT)         =    0.00
BLDG ON-SITE UTILITIES ($/SQFT)    =    0.00
BLDG OFF-SITE UTILITIES ($/SQFT)   =    0.00
PRIVATE INSURANCE ($/SQFT)         =    0.41
REVENUE FR GVMT LAND LEASE (M$/YR) =    0.11
FEE (%)                            =    0.0%
METHOD                             = OMB
*****************************************    ****************************************************************************************************
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                                         SUMMARY RESULTS                                          P.    4
                                                                                           SSPFBL2
                                 SPACE STATION PROCESSING FACILITY                         02/01/89 01:25 PM

                                 3RD PARTY                3RD PARTY
                                 ACTUAL                   NPV
                                 DOLLARS                  DOLLARS
                                 ---------                ---------

100 % GOVERNMENT OWNED-OMB        211.30                    87.39

100 % GOVERNMENT OWNED-GAO        211.30                    88.87

 80 % GOVERNMENT OWNED-OMB        169.04                    69.91

 80 % GOVERNMENT OWNED-GAO        169.04                    71.09


COF ACTUAL DOLLARS   84.00 M

COF NPV-OMB          73.66 M

COF NPV-GAO          73.86 M

NOTES:  NPV DISCOUNTED BACK TO JAN 1, 1989
        DESIGN COMPLETION FOR CASE 2(INCLUDES 3RD FLOOR) IS OCT 1, 1989
        OMB DISCOUNT RATE = 9.3 %   AND GAO DISCOUNT RATE = 9.1 %
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JET PROPULSION LABORATORY

OBSERVATIONAL INSTRUMENTS LAB

20 % FINANCIER-OWNED

80 % GOVERNMENT-OWNED

JANUARY 31, 1989

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OIL28          CENTER : JPL                          FACILITY :    OBSERVATIONAL INSTRUMENTS LAB                                          P.    1
12:58 PM       $$MILLIONS                      C OF F CONSTRUCTION VS. 3RD PARTY FINANCING OF FACILITIES
02/01/89                                                GOVERENMENT OWNS 80% OF FACILITY=$11.2M
                                              FINANCIER OWNS 20% OF FACILITY=$ 2.8M    TOTAL ASSET VALUE = $14M

         PROJECT YEAR #                   0      1      2      3      4      5      6      7      8      9     10     11     12     13     14     15
         FISCAL YEAR                   1989   1990   1991   1992   1993   1994   1995   1996   1997   1998   1999   2000   2001   2002   2003   2004

         <<<C OF F CASE>>>
         NEW BUILDING COST             0.00  13.40   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
         BUILDING MAINTENANCE          0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
         OTHER COSTS--UTIL ON SITE     0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
         RESIDUAL VALUE                0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
                 TOTAL                 0.00  13.40   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
                 TOTAL W/INFLATION     0.00  14.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00

         <<<3RD PARTY FINANCING CASE>>>
         OTHER COSTS #1--INSURANCE     0.00   0.00   0.01   0.03   0.03   0.03   0.03   0.03   0.03   0.03   0.03   0.03   0.03   0.03   0.03   0.03
         OTHER COSTS #2--UTIL ON SIT   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
         OTHER REVENUE--LAND LEASE     0.00   0.00   0.03   0.11   0.11   0.11   0.11   0.11   0.11   0.11   0.11   0.11   0.11   0.11   0.11   0.11
         BUILDING MAINTENANCE          0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
         YEARLY PAYMENT                0.00   0.00   0.40   1.70   1.70   1.70   1.70   1.70   1.70   1.70   1.70   1.70   1.70   1.70   1.70   1.70
         RESIDUAL VALUE                0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
                 TOTAL                 0.00   0.00   0.38   1.62   1.62   1.62   1.62   1.62   1.62   1.62   1.62   1.62   1.62   1.62   1.62   1.62
                 TOTAL W/INFLATION     0.00   0.00   0.38   1.61   1.61   1.60   1.60   1.59   1.59   1.59   1.58   1.57   1.57   1.56   1.56   1.55

PROGRAM COSTS -- ALTERNATE #1 (COFF)   0.00  14.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
PROGRAM COSTS -- ALTERNATE #2 (3P)     0.00   0.00   0.38   1.61   1.61   1.60   1.60   1.59   1.59   1.59   1.58   1.57   1.57   1.56   1.56   1.55
          PTL -- ALTERNATE #2 (3P)                  12.82  12.73  12.33  11.89  11.40  10.87  10.27   9.62   8.89   8.09   7.21   6.23   5.15   3.95

   NET PRESENT VALUE OF ALTERNATIVES
NPV COFF -- OMB DISCOUNT RATE          0.00  12.81  12.81  12.81  12.81  12.81  12.81  12.81  12.81  12.81  12.81  12.81  12.81  12.81  12.81  12.81
NPV 3RDP -- OMB DISCOUNT RATE          0.00   0.00   0.32   1.55   2.68   3.71   4.64   5.50   6.28   6.99   7.64   8.23   8.77   9.27   9.71  10.12

NPV COFF -- GAO DISCOUNT RATE          0.00  12.83  12.83  12.83  12.83  12.83  12.83  12.83  12.83  12.83  12.83  12.83  12.83  12.83  12.83  12.83
NPV 3RDP -- GAO DISCOUNT RATE          0.00   0.00   0.32   1.56   2.69   3.73   4.68   5.55   6.34   7.06   7.73   8.33   8.88   9.38   9.84  10.26
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OBSERVATIONAL INSTRUMENTS LAB                                        P.    2

                                                                   OIL28

   16     17     18
 2005   2006   2007


 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00


 0.03   0.02   0.00
 0.00   0.00   0.00
 0.11   0.08   0.00
 0.00   0.00   0.00
 1.70   1.30   0.00
 0.00   0.00   0.00
 1.62   1.24   0.00
 1.54   1.18   0.00

 0.00   0.00   0.00
 1.54   1.18   0.00
 2.64   1.18   0.00


12.81  12.81  12.81
10.50  10.76  10.76

12.83  12.83  12.83
10.65  10.92  10.92
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OIL28                                                          OBSERVATIONAL INSTRUMENTS LAB
02/01/89 12:58 PM                                                  80% GOVERNMENT OWNED
                                                                          OMB
**************** INPUTS ****************   ******************************************** OUTPUTS ********************************************   P.    3
PRIME RATE @12/01/88               =    10.5%      CUM NASA OUTLAYS, MILLIONS OF CURRENT DOLLARS              NASA OUTLAYS $M (DISCOUNTED)
START YEAR 3RD PARTY               =     1990                        CoFF  3RDPARTY                               CoFF  3RDPARTY
START MONTH (1,2, ETC) 3RD PARTY   =        1                        0.00    0.00           FY89                   0.00    0.00
CONSTRUCTION DURATIN (MO) 3RD PARTY=       18                       14.00    0.00  3P       FY90                  12.81    0.00  3P
POPULATION  (1994 ON OUT)          =        0                       14.00    0.38  3P       FY91                  12.81    0.32  3P
LEASE PAYMENT ($/SQFT/YR)          =     0.00                       14.00    1.99  3P       FY92                  12.81    1.55  3P
LEASE MTC. ($/SQFT/YR)             =     0.00                       14.00    3.60  3P       FY93                  12.81    2.68  3P
LEASE SQFT/PERSON                  =     0.00                       14.00    5.20  3P       FY94                  12.81    3.71  3P
LEASE INEFFICIENCIES ($M/YR)       =     0.00                       14.00    6.80  3P       FY95                  12.81    4.64  3P
BUILDING COST ($M)                 =    14.00                       14.00    8.40  3P       FY96                  12.81    5.50  3P
GVMT SHARE OF BUILDING COST ($M)   =    11.20                       14.00    9.99  3P       FY97                  12.81    6.28  3P
BUILDING MTC. ($/SQFT/YR)          =     0.00                       14.00   11.57  3P       FY98                  12.81    6.99  3P
BUILDING SIZE (K SQFT)             =    80.00                       14.00   13.15  3P       FY99                  12.81    7.64  3P
DISCOUNT RATE      (OMB)           =     9.3%                       14.00   14.73  C OF F   FY00                  12.81    8.23  3P
TERM (YRS)                         =       15                       14.00   16.30  C OF F   FY01                  12.81    8.77  3P
INFLATION                          =     4.5%                       14.00   17.86  C OF F   FY02                  12.81    9.27  3P
RESIDUAL VALUE (TODAY'S $M)        =       10                       14.00   19.42  C OF F   FY03                  12.81    9.71  3P
RATE OF INTEREST DURING CONST.     =    12.5%                       14.00   20.97  C OF F   FY04                  12.81   10.12  3P
START YEAR CoFF CONSTRUCTION       =     1990                       14.00   22.51  C OF F   FY05                  12.81   10.50  3P
START MONTH CoFF                   =        1                       14.00   23.69  C OF F   FY06                  12.81   10.76  3P
CONSTRUCTION DURATION (MO) CoFF    =       18   ----> 15 YEARS AMORTIZATION  14.00   23.69  C OF F   FY07      12.81   10.76  3P
TRAILER REPLACEMENT ($M EA. 10YR)  =        0
START YEAR OF ANALYSIS             =     1989
RATE OF INTEREST LONG-TERM LOAN    =    10.5%
TRAILER MAINTENANCE ($/SQFT)       =     0.00
TRAILER UTILITIES ($/SQFT)         =     0.00
BLDG ON-SITE UTILITIES ($/SQFT)    =     0.00
BLDG OFF-SITE UTILITIES ($/SQFT)   =     0.00
PRIVATE INSURANCE ($/SQFT)         =     0.41
REVENUE FR GVMT LAND LEASE (M$/YR) =     0.11
FEE (%)                            =     0.0%
METHOD                             = OMB
*****************************************   ****************************************************************************************************
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                                        SUMMARY RESULTS                                      P.    4

                                  OBSERVATIONAL INSTRUMENTS LAB                          OIL2
                                                                                         02/01/89 01:01 PM

                              3RD PARTY          3RD PARTY
                              ACTUAL             NPV
                              DOLLARS            DOLLARS
                              ---------          ---------

100 % GOVERNMENT OWNED-OMB      31.09              14.11

100 % GOVERNMENT OWNED-GAO      31.09              14.32

 80 % GOVERNMENT OWNED-OMB      24.87              11.29

 80 % GOVERNMENT OWNED-GAO      24.87              11.46


COF ACTUAL DOLLARS   14.00 M

COF NPV-OMB          12.81 M

COF NPV-GAO          12.83 M

NOTES:  NPV DISCOUNTED BACK TO JAN 1, 1989
        OMB DISCOUNT RATE = 9.3 %   AND GAO DISCOUNT RATE = 9.1 %
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JET PROPULSION LABORATORY

OBSERVATIONAL INSTRUMENTS LAB

100 % GOVERNMENT-OWNED

JANUARY 31, 1989

OIL2
01:01 PM
02/01/89

CENTER : JPL
$$MILLIONS

FACILITY : OBSERVATIONAL INSTRUMENTS LAB
C OF F CONSTRUCTION VS. 3RD PARTY FINANCING OF FACILITIES

GOVERENMENT OWNS 100% OF FACILITY=$14M

PROJECT YEAR #	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FISCAL YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
<<<C OF F CASE>>>																
NEW BUILDING COST	0.00	13.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BUILDING MAINTENANCE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER COSTS--UTIL ON SITE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESIDUAL VALUE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	0.00	13.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL W/INFLATION	0.00	14.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<<<3RD PARTY FINANCING CASE>>>																
OTHER COSTS #1--INSURANCE	0.00	0.00	0.01	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
OTHER COSTS #2--UTIL ON SIT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER REVENUE--LAND LEASE	0.00	0.00	0.03	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
BUILDING MAINTENANCE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
YEARLY PAYMENT	0.00	0.00	0.50	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
RESIDUAL VALUE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	0.00	0.00	0.48	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
TOTAL W/INFLATION	0.00	0.00	0.48	2.11	2.11	2.10	2.10	2.09	2.09	2.09	2.08	2.07	2.07	2.06	2.06	2.05
PROGRAM COSTS -- ALTERNATE #1 (COFF)	0.00	14.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PROGRAM COSTS -- ALTERNATE #2 (3P)	0.00	0.00	0.48	2.11	2.11	2.10	2.10	2.09	2.09	2.09	2.08	2.07	2.07	2.06	2.06	2.05
PTL -- ALTERNATE #2 (3P)			16.03	15.91	15.41	14.86	14.25	13.58	12.84	12.02	11.12	10.11	9.01	7.79	6.44	4.94
NET PRESENT VALUE OF ALTERNATIVES																
NPV COFF -- OMB DISCOUNT RATE	0.00	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81
NPV 3RDP -- OMB DISCOUNT RATE	0.00	0.00	0.40	2.02	3.50	4.84	6.08	7.20	8.23	9.16	10.02	10.80	11.51	12.16	12.75	13.29
NPV COFF -- GAO DISCOUNT RATE	0.00	12.83	12.83	12.83	12.83	12.83	12.83	12.83	12.83	12.83	12.83	12.83	12.83	12.83	12.83	12.83
NPV 3RDP -- GAO DISCOUNT RATE	0.00	0.00	0.40	2.03	3.52	4.88	6.12	7.26	8.30	9.25	10.13	10.92	11.65	12.31	12.92	13.48

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OBSERVATIONAL INSTRUMENTS LAB                                                                                                   P.     2

                                                                                                                             OIL2

     16      17      18
   2005    2006    2007


   0.00    0.00    0.00
   0.00    0.00    0.00
   0.00    0.00    0.00
   0.00    0.00    0.00
   0.00    0.00    0.00
   0.00    0.00    0.00


   0.03    0.02    0.00
   0.00    0.00    0.00
   0.11    0.08    0.00
   0.00    0.00    0.00
   2.20    1.60    0.00
   0.00    0.00    0.00
   2.12    1.54    0.00
   2.04    1.48    0.00

   0.00    0.00    0.00
   2.04    1.48    0.00
   3.29    1.47    0.00


  12.81   12.81   12.81
  13.78   14.11   14.11

  12.83   12.83   12.83
  13.98   14.32   14.32
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OIL2                                                                   OBSERVATIONAL INSTRUMENTS LAB
02/01/89 01:01 PM                                                      100% GOVERNMENT OWNED
                                                                                OMB
**************** INPUTS *****************         ******************************************** OUTPUTS ********************************************        P.    3
PRIME RATE @12/01/88                 =    10.5%        CUM NASA OUTLAYS, MILLIONS OF CURRENT DOLLARS          NASA OUTLAYS $M (DISCOUNTED)
START YEAR 3RD PARTY                 =    1990                          CoFF  3RDPARTY                          CoFF  3RDPARTY
START MONTH (1,2, ETC) 3RD PARTY     =       1                          0.00   0.00          FY89               0.00   0.00
CONSTRUCTION DURATIN (MO) 3RD PARTY=        18                         14.00   0.00  3P      FY90              12.81   0.00  3P
POPULATION  (1994 ON OUT)            =       0                         14.00   0.48  3P      FY91              12.81   0.40  3P
LEASE PAYMENT ($/SQFT/YR)            =    0.00                         14.00   2.59  3P      FY92              12.81   2.02  3P
LEASE MTC. ($/SQFT/YR)               =    0.00                         14.00   4.70  3P      FY93              12.81   3.50  3P
LEASE SQFT/PERSON                    =    0.00                         14.00   6.80  3P      FY94              12.81   4.84  3P
LEASE INEFFICIENCIES ($M/YR)         =    0.00                         14.00   8.90  3P      FY95              12.81   6.08  3P
BUILDING COST ($M)                   =   14.00                         14.00  11.00  3P      FY96              12.81   7.20  3P
GVMT SHARE OF BUILDING COST ($M)     =   14.00                         14.00  13.09  3P      FY97              12.81   8.23  3P
BUILDING MTC. ($/SQFT/YR)            =    0.00                         14.00  15.17  C OF F  FY98              12.81   9.16  3P
BUILDING SIZE (K SQFT)               =   80.00                         14.00  17.25  C OF F  FY99              12.81  10.02  3P
DISCOUNT RATE      (OMB)             =     9.3%                        14.00  19.33  C OF F  FY00              12.81  10.80  3P
TERM (YRS)                           =      15                         14.00  21.40  C OF F  FY01              12.81  11.51  3P
INFLATION                            =     4.5%                        14.00  23.46  C OF F  FY02              12.81  12.16  3P
RESIDUAL VALUE (TODAY'S $M)          =      10                         14.00  25.52  C OF F  FY03              12.81  12.75  3P
RATE OF INTEREST DURING CONST.       =    12.5%                        14.00  27.57  C OF F  FY04              12.81  13.29  C OF F
START YEAR CoFF CONSTRUCTION         =    1990                         14.00  29.61  C OF F  FY05              12.81  13.78  C OF F
START MONTH CoFF                     =       1                         14.00  31.09  C OF F  FY06              12.81  14.11  C OF F
CONSTRUCTION DURATION (MO) CoFF      =      18  ----> 15 YEARS AMORTIZATION  14.00  31.09  C OF F  FY07        12.81  14.11  C OF F
TRAILER REPLACEMENT ($M EA. 10YR)    =       0
START YEAR OF ANALYSIS               =    1989
RATE OF INTEREST LONG-TERM LOAN      =    10.5%
TRAILER MAINTENANCE ($/SQFT)         =    0.00
TRAILER UTILITIES ($/SQFT)           =    0.00
BLDG ON-SITE UTILITIES ($/SQFT)      =    0.00
BLDG OFF-SITE UTILITIES ($/SQFT)     =    0.00
PRIVATE INSURANCE ($/SQFT)           =    0.41
REVENUE FR GVMT LAND LEASE (M$/YR)   =    0.11
FEE (%)                              =     0.0%
METHOD                               = OMB
******************************************         ******************************************************************************************
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SUMMARY RESULTS

OBSERVATIONAL INSTRUMENTS LAB

	3RD PARTY ACTUAL DOLLARS	3RD PARTY NPV DOLLARS
100 % GOVERNMENT OWNED-OMB	31.09	14.11
100 % GOVERNMENT OWNED-GAO	31.09	14.32
80 % GOVERNMENT OWNED-OMB	24.87	11.29
80 % GOVERNMENT OWNED-GAO	24.87	11.46

COF ACTUAL DOLLARS	14.00 M
COF NPV-OMB	12.81 M
COF NPV-GAO	12.83 M

NOTES: NPV DISCOUNTED BACK TO JAN 1, 1989
OMB DISCOUNT RATE = 9.3 % AND GAO DISCOUNT RATE = 9.1 %

JOHNSON SPACE CENTER

NEUTRAL BUOYANCY LAB

20 % FINANCIER-OWNED

80 % GOVERNMENT-OWNED

JANUARY 31, 1989

NBL28 CENTER : JSC
01:14 PM $$MILLIONS
02/01/89

FACILITY : NEUTRAL BUOYANCY LAB
C OF F CONSTRUCTION VS. 3RD PARTY FINANCING OF FACILITIES
GOVERENMENT OWNS 80% OF FACILITY=$24M
FINANCIER RETAINS 20% OF ASSET VALUE ($6M) TOTAL ASSET VALUE = $30M

PROJECT YEAR #	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FISCAL YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
<<<C OF F CASE>>>																
NEW BUILDING COST	0.00	28.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BUILDING MAINTENANCE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER COSTS--UTIL ON SITE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESIDUAL VALUE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	0.00	28.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL W/INFLATION	0.00	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<<<3RD PARTY FINANCING CASE>>>																
OTHER COSTS #1--INSURANCE	0.00	0.00	0.01	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
OTHER COSTS #2--UTIL ON SIT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER REVENUE--LAND LEASE	0.00	0.00	0.03	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
BUILDING MAINTENANCE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
YEARLY PAYMENT	0.00	0.00	0.90	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70
RESIDUAL VALUE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	0.00	0.00	0.88	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62
TOTAL W/INFLATION	0.00	0.00	0.88	3.61	3.61	3.60	3.60	3.59	3.59	3.58	3.58	3.57	3.57	3.56	3.55	3.55
PROGRAM COSTS -- ALTERNATE #1 (CofF)	0.00	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PROGRAM COSTS -- ALTERNATE #2 (3P)	0.00	0.00	0.88	3.61	3.61	3.60	3.60	3.59	3.59	3.58	3.58	3.57	3.57	3.56	3.55	3.55
PTL -- ALTERNATE #2 (3P)			27.48	27.27	26.42	25.48	24.44	23.28	22.01	20.61	19.05	17.34	15.44	13.35	11.03	8.47
NET PRESENT VALUE OF ALTERNATIVES																
NPV CofF -- OMB DISCOUNT RATE	0.00	27.45	27.45	27.45	27.45	27.45	27.45	27.45	27.45	27.45	27.45	27.45	27.45	27.45	27.45	27.45
NPV 3RDP -- OMB DISCOUNT RATE	0.00	0.00	0.74	3.50	6.03	8.34	10.45	12.37	14.13	15.74	17.21	18.56	19.78	20.90	21.93	22.86
NPV CofF -- GAO DISCOUNT RATE	0.00	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50
NPV 3RDP -- GAO DISCOUNT RATE	0.00	0.00	0.74	3.52	6.06	8.39	10.53	12.48	14.27	15.90	17.40	18.77	20.02	21.17	22.22	23.18

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   16     17     18
 2005   2006   2007


 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00


 0.03   0.02   0.00
 0.00   0.00   0.00
 0.11   0.08   0.00
 0.00   0.00   0.00
 3.70   2.80   0.00
 0.00   0.00   0.00
 3.62   2.74   0.00
 3.54   2.68   0.00

 0.00   0.00   0.00
 3.54   2.68   0.00
 5.65   2.52   0.00


27.45  27.45  27.45
23.72  24.31  24.31

27.50  27.50  27.50
24.06  24.67  24.67
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NBL28                                                                    NEUTRAL BUOYANCY LAB
02/01/89 10:46 AM                                                        80% GOVERNMENT OWNED
                                                                                 OMB
**************** INPUTS ****************     ********************************************** OUTPUTS **********************************************     P.   3
PRIME RATE @12/01/88               =   10.5%       CUM NASA OUTLAYS, MILLIONS OF CURRENT DOLLARS           NASA OUTLAYS $M (DISCOUNTED)
START YEAR 3RD PARTY               =   1990                          CofF  3rdPARTY                             CofF  3rdPARTY
START MONTH (1,2, ETC) 3RD PARTY   =      1                          0.00    0.00           FY89                0.00    0.00
CONSTRUCTION DURATIN (MO) 3RD PARTY=     18                         30.00    0.00  3P       FY90               27.45    0.00  3P
POPULATION  (1994 ON OUT)          =      0                         30.00    0.88  3P       FY91               27.45    0.74  3P
LEASE PAYMENT ($/SQFT/YR)          =   0.00                         30.00    4.49  3P       FY92               27.45    3.50  3P
LEASE MTC. ($/SQFT/YR)             =   0.00                         30.00    8.09  3P       FY93               27.45    6.03  3P
LEASE SQFT/PERSON                  =   0.00                         30.00   11.70  3P       FY94               27.45    8.34  3P
LEASE INEFFICIENCIES ($M/YR)       =   0.00                         30.00   15.29  3P       FY95               27.45   10.45  3P
BUILDING COST ($M)                 =  30.00                         30.00   18.89  3P       FY96               27.45   12.37  3P
GVMT SHARE OF BUILDING COST ($M)   =  24.00                         30.00   22.47  3P       FY97               27.45   14.13  3P
BUILDING MTC. ($/SQFT/YR)          =   0.00                         30.00   26.06  3P       FY98               27.45   15.74  3P
BUILDING SIZE (K SQFT)             =  76.00                         30.00   29.63  3P       FY99               27.45   17.21  3P
DISCOUNT RATE      (OMB)           =    9.3%                        30.00   33.21  C OF F   FY00               27.45   18.56  3P
TERM (YRS)                         =     15                         30.00   36.77  C OF F   FY01               27.45   19.78  3P
INFLATION                          =    4.5%                        30.00   40.33  C OF F   FY02               27.45   20.90  3P
RESIDUAL VALUE (TODAY'S $M)        =     10                         30.00   43.89  C OF F   FY03               27.45   21.93  3P
RATE OF INTEREST DURING CONST.     =   12.5%                        30.00   47.43  C OF F   FY04               27.45   22.86  3P
START YEAR CofF CONSTRUCTION       =   1990                         30.00   50.98  C OF F   FY05               27.45   23.72  3P
START MONTH CofF                   =      1                         30.00   53.65  C OF F   FY06               27.45   24.31  3P
CONSTRUCTION DURATION (MO) CofF    =     18    ----> 15 YEARS AMORTIZATION  30.00   53.65  C OF F   FY07               27.45   24.31  3P
TRAILER REPLACEMENT ($M EA. 10YR)  =      0
START YEAR OF ANALYSIS             =   1989
RATE OF INTEREST LONG-TERM LOAN    =   10.5%
TRAILER MAINTENANCE ($/SQFT)       =   0.00
TRAILER UTILITIES ($/SQFT)         =   0.00
BLDG ON-SITE UTILITIES ($/SQFT)    =   0.00
BLDG OFF-SITE UTILITIES ($/SQFT)   =   0.00
PRIVATE INSURANCE ($/SQFT)         =   0.41
REVENUE FR GVMT LAND LEASE (M$/YR) =   0.11
FEE (%)                            =    0.0%
METHOD                             = OMB
*****************************************     ***************************************************************************************************
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SUMMARY RESULTS

NEUTRAL BUOYANCY LAB

	3RD PARTY ACTUAL DOLLARS	3RD PARTY NPV DOLLARS
100 % GOVERNMENT OWNED-OMB	67.25	30.48
100 % GOVERNMENT OWNED-GAO	67.25	30.94
80 % GOVERNMENT OWNED-OMB	53.80	24.38
80 % GOVERNMENT OWNED-GAO	53.80	24.75

COF ACTUAL DOLLARS	30.00 M
COF NPV-OMB	27.45 M
COF NPV-GAO	27.50 M

NOTES: NPV DISCOUNTED BACK TO JAN 1, 1989
OMB DISCOUNT RATE = 9.3 % AND GAO DISCOUNT RATE = 9.1 %

SUMMARY RESULTS

NEUTRAL BUOYANCY LAB

	3RD PARTY ACTUAL DOLLARS	3RD PARTY NPV DOLLARS
100 % GOVERNMENT OWNED-OMB	67.25	30.48
100 % GOVERNMENT OWNED-GAO	67.25	30.94
80 % GOVERNMENT OWNED-OMB	53.80	24.38
80 % GOVERNMENT OWNED-GAO	53.80	24.75

COF ACTUAL DOLLARS	30.00 M
COF NPV-OMB	27.45 M
COF NPV-GAO	27.50 M

NOTES: NPV DISCOUNTED BACK TO JAN 1, 1989
DESIGN COMPLETION FOR CASE 2(INCLUDES 3RD FLOOR) IS OCT 1, 1989
OMB DISCOUNT RATE = 9.3 % AND GAO DISCOUNT RATE = 9.1 %

JOHNSON SPACE CENTER

NEUTRAL BUOYANCY LAB

100 % GOVERNMENT-OWNED

JANUARY 31, 1989

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NBL2           CENTER : JSC                       FACILITY :    NEUTRAL BUOYANCY LAB                                                  P.     1
01:13 PM       $$MILLIONS                  C OF F CONSTRUCTION vs. 3RD PARTY FINANCING OF FACILITIES
02/01/89
                                                    GOVERENMENT OWNS 100% OF FACILITY=$30M

      PROJECT YEAR #                  0      1      2      3      4      5      6      7      8      9     10     11     12     13     14     15
      FISCAL YEAR                  1989   1990   1991   1992   1993   1994   1995   1996   1997   1998   1999   2000   2001   2002   2003   2004

      <<<C OF F CASE>>>
      NEW BUILDING COST            0.00  28.71   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
      BUILDING MAINTENANCE         0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
      OTHER COSTS--UTIL ON SITE    0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
      RESIDUAL VALUE               0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
             TOTAL                 0.00  28.71   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
             TOTAL W/INFLATION     0.00  30.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00

      <<<3RD PARTY FINANCING CASE>>>
      OTHER COSTS #1--INSURANCE    0.00   0.00   0.01   0.03   0.03   0.03   0.03   0.03   0.03   0.03   0.03   0.03   0.03   0.03   0.03   0.03
      OTHER COSTS #2--UTIL ON SIT  0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
      OTHER REVENUE--LAND LEASE    0.00   0.00   0.03   0.11   0.11   0.11   0.11   0.11   0.11   0.11   0.11   0.11   0.11   0.11   0.11   0.11
      BUILDING MAINTENANCE         0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
      YEARLY PAYMENT               0.00   0.00   1.20   4.60   4.60   4.60   4.60   4.60   4.60   4.60   4.60   4.60   4.60   4.60   4.60   4.60
      RESIDUAL VALUE               0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
             TOTAL                 0.00   0.00   1.18   4.52   4.52   4.52   4.52   4.52   4.52   4.52   4.52   4.52   4.52   4.52   4.52   4.52
             TOTAL W/INFLATION     0.00   0.00   1.18   4.51   4.51   4.50   4.50   4.49   4.49   4.48   4.48   4.47   4.47   4.46   4.45   4.45

PROGRAM COSTS -- ALTERNATE #1 (CoFF) 0.00  30.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
PROGRAM COSTS -- ALTERNATE #2 (3P)   0.00   0.00   1.18   4.51   4.51   4.50   4.50   4.49   4.49   4.48   4.48   4.47   4.47   4.46   4.45   4.45
          PTL -- ALTERNATE #2 (3P)                34.35  34.09  33.02  31.85  30.54  29.11  27.52  25.76  23.82  21.67  19.30  16.68  13.79  10.59

   NET PRESENT VALUE OF ALTERNATIVES
NPV CoFF -- OMB DISCOUNT RATE        0.00  27.45  27.45  27.45  27.45  27.45  27.45  27.45  27.45  27.45  27.45  27.45  27.45  27.45  27.45  27.45
NPV 3RDP -- OMB DISCOUNT RATE        0.00   0.00   0.99   4.44   7.60  10.48  13.12  15.53  17.74  19.75  21.59  23.27  24.81  26.21  27.49  28.67

NPV CoFF -- GAO DISCOUNT RATE        0.00  27.50  27.50  27.50  27.50  27.50  27.50  27.50  27.50  27.50  27.50  27.50  27.50  27.50  27.50  27.50
NPV 3RDP -- GAO DISCOUNT RATE        0.00   0.00   0.99   4.46   7.64  10.56  13.22  15.66  17.90  19.95  21.82  23.54  25.11  26.55  27.86  29.07
```

NBL2

```
   16     17     18
 2005   2006   2007


 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00
 0.00   0.00   0.00


 0.03   0.02   0.00
 0.00   0.00   0.00
 0.11   0.08   0.00
 0.00   0.00   0.00
 4.60   3.50   0.00
 0.00   0.00   0.00
 4.52   3.44   0.00
 4.44   3.38   0.00

 0.00   0.00   0.00
 4.44   3.38   0.00
 7.06   3.15   0.00


27.45  27.45  27.45
29.74  30.48  30.48

27.50  27.50  27.50
30.17  30.94  30.94
```

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NBL2                                                              NEUTRAL BUOYANCY LAB
02/01/89 10:36 AM                                                 100% GOVERNMENT OWNED
                                                                           OMB
**************** INPUTS ****************     ******************************************** OUTPUTS ********************************************      P.    3
PRIME RATE @12/01/88                  =    10.5%        CUM NASA OUTLAYS, MILLIONS OF CURRENT DOLLARS              NASA OUTLAYS $M (DISCOUNTED)
START YEAR 3RD PARTY                  =     1990                            CoFF  3RDPARTY                                   CoFF  3RDPARTY
START MONTH (1,2, ETC) 3RD PARTY      =        1                            0.00    0.00               FY89                  0.00    0.00
CONSTRUCTION DURATIN (MO) 3RD PARTY=          18                           30.00    0.00 3P            FY90                 27.45    0.00 3P
POPULATION  (1994 ON OUT)             =        0                           30.00    1.18 3P            FY91                 27.45    0.99 3P
LEASE PAYMENT ($/SQFT/YR)             =     0.00                           30.00    5.69 3P            FY92                 27.45    4.44 3P
LEASE MTC. ($/SQFT/YR)                =     0.00                           30.00   10.19 3P            FY93                 27.45    7.60 3P
LEASE SQFT/PERSON                     =     0.00                           30.00   14.70 3P            FY94                 27.45   10.48 3P
LEASE INEFFICIENCIES ($M/YR)          =     0.00                           30.00   19.19 3P            FY95                 27.45   13.12 3P
BUILDING COST ($M)                    =    30.00                           30.00   23.69 3P            FY96                 27.45   15.53 3P
GVMT SHARE OF BUILDING COST ($M)      =    30.00                           30.00   28.17 3P            FY97                 27.45   17.74 3P
BUILDING MTC. ($/SQFT/YR)             =     0.00                           30.00   32.66 C OF F        FY98                 27.45   19.75 3P
BUILDING SIZE (K SQFT)                =    76.00                           30.00   37.13 C OF F        FY99                 27.45   21.59 3P
DISCOUNT RATE      (OMB)              =     9.3%                           30.00   41.61 C OF F        FY00                 27.45   23.27 3P
TERM (YRS)                            =       15                           30.00   46.07 C OF F        FY01                 27.45   24.81 3P
INFLATION                             =     4.5%                           30.00   50.53 C OF F        FY02                 27.45   26.21 3P
RESIDUAL VALUE (TODAY'S $M)           =       10                           30.00   54.99 C OF F        FY03                 27.45   27.49 C OF F
RATE OF INTEREST DURING CONST.        =    12.5%                           30.00   59.43 C OF F        FY04                 27.45   28.67 C OF F
START YEAR CoFF CONSTRUCTION          =     1990                           30.00   63.88 C OF F        FY05                 27.45   29.74 C OF F
START MONTH CoFF                      =        1                           30.00   67.25 C OF F        FY06                 27.45   30.48 C OF F
CONSTRUCTION DURATION (MO) CoFF       =       18   ----) 15 YEARS AMORTIZATION   30.00   67.25 C OF F  FY07                 27.45   30.48 C OF F
TRAILER REPLACEMENT ($M EA. 10YR)     =        0
START YEAR OF ANALYSIS                =     1989
RATE OF INTEREST LONG-TERM LOAN       =    10.5%
TRAILER MAINTENANCE ($/SQFT)          =     0.00
TRAILER UTILITIES ($/SQFT)            =     0.00
BLDG ON-SITE UTILITIES ($/SQFT)       =     0.00
BLDG OFF-SITE UTILITIES ($/SQFT)      =     0.00
PRIVATE INSURANCE ($/SQFT)            =     0.41
REVENUE FR GVMT LAND LEASE (M$/YR)    =     0.11
FEE (%)                               =     0.0%
METHOD                                = OMB
****************************************     ***************************************************************************************************
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                                   SUMMARY RESULTS                                        P.    4
                                                                                 NBL2
                                 NEUTRAL BUOYANCY LAB                            02/01/89 01:13 PM

                            3RD PARTY            3RD PARTY
                            ACTUAL               NPV
                            DOLLARS              DOLLARS
                            ---------            ---------

100 % GOVERNMENT OWNED-OMB    67.25                30.48

100 % GOVERNMENT OWNED-GAO    67.25                30.94

 80 % GOVERNMENT OWNED-OMB    53.80                24.38

 80 % GOVERNMENT OWNED-GAO    53.80                24.75


COF ACTUAL DOLLARS   30.00 M

COF NPV-OMB          27.45 M

COF NPV-GAO          27.50 M

NOTES:  NPV DISCOUNTED BACK TO JAN 1, 1989
        OMB DISCOUNT RATE = 9.3 %   AND GAO DISCOUNT RATE = 9.1 %
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NASA LYNDON B. JOHNSON SPACE CENTER

MAN-SYSTEMS DIVISION

NEUTRAL
BUOYANCY
LABORATORY

NBL

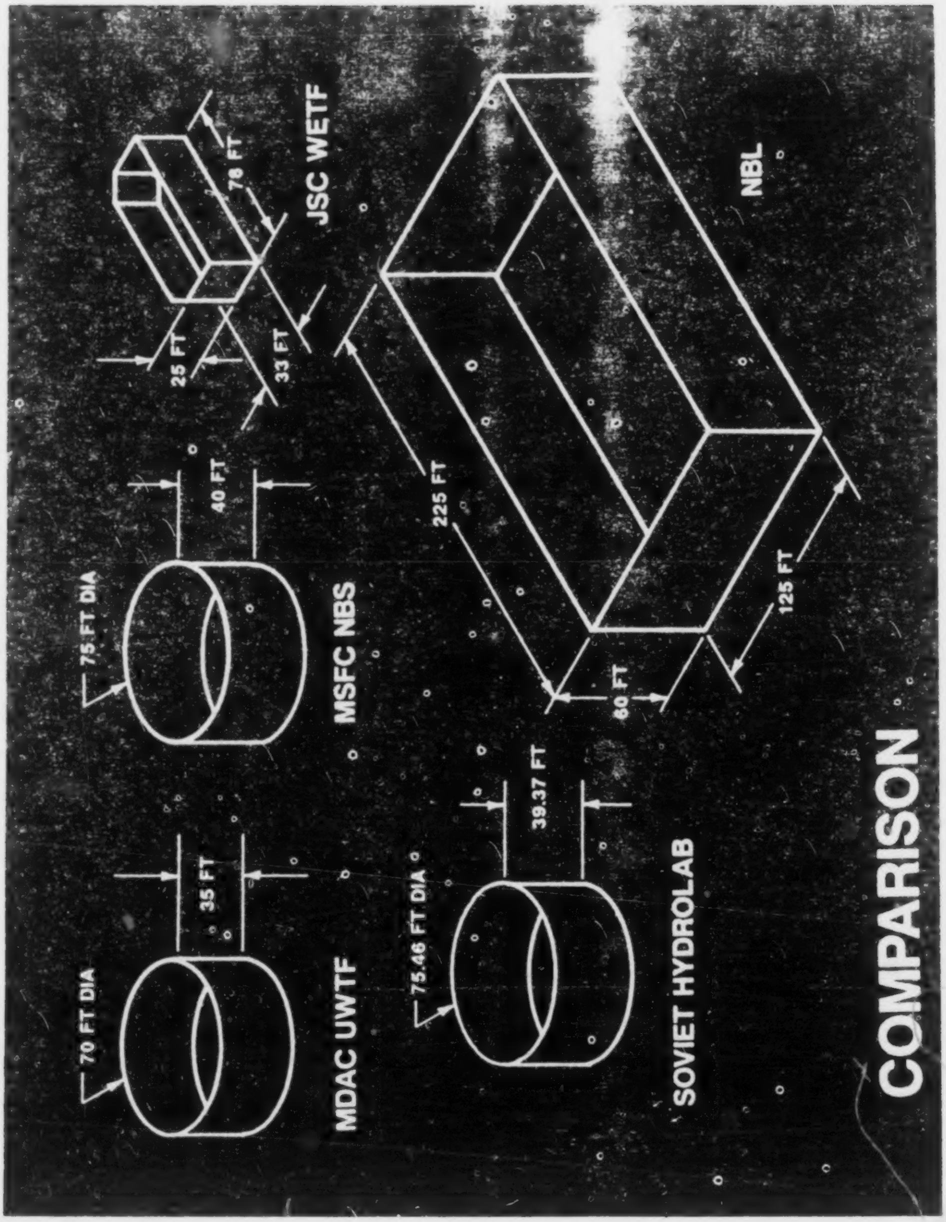
NEUTRAL BUOYANCY LABORATORY

THE NBL IS A LARGE NEUTRAL BUOYANCY SIMULATION FACILITY WHOSE PRIMARY FUNCTION IS SUPPORTING EVA ACTIVITIES INVOLVING LARGE STRUCTURES, PAYLOADS, AND PAYLOAD ASSEMBLIES FOR THE STS, SPACE STATION, AND FUTURE PROGRAMS.

EXISTING FACILITIES ARE INADEQUATE

THE EXISTING NEUTRAL BUOYANCY FACILITIES ARE INADEQUATE, DUE TO SMALL SIZE, TO SUPPORT CURRENT, PLANNED, AND FUTURE SPACE PROGRAMS.

MSFC	NEUTRAL BUOYANCY SIMULATOR (NBS)
JSC	WEIGHTLESS ENVIRONMENT TRAINING FACILITY (WETF)
U.S. NAVY	
COMMERCIAL	MDAC UNDERWATER TEST FACILITY (UWTF)


70 FT DIA
35 FT
MDAC UWTF
75 FT DIA
40 FT
MSFC NBS
25 FT
33 FT
78 FT
JSC WETF
75.46 FT DIA
39.37 FT
SOVIET HYDROLAB
225 FT
60 FT
125 FT
NBL

COMPARISON

THE NEUTRAL BUOYANCY SIMULATION PRODUCTS ARE:

- ENGINEERING EVALUATIONS
- PROCEDURE VERIFICATION
- EVA ASTRONAUT CREW TRAINING
- REAL TIME MISSION SUPPORT

WETF DESIGN LIMITATION

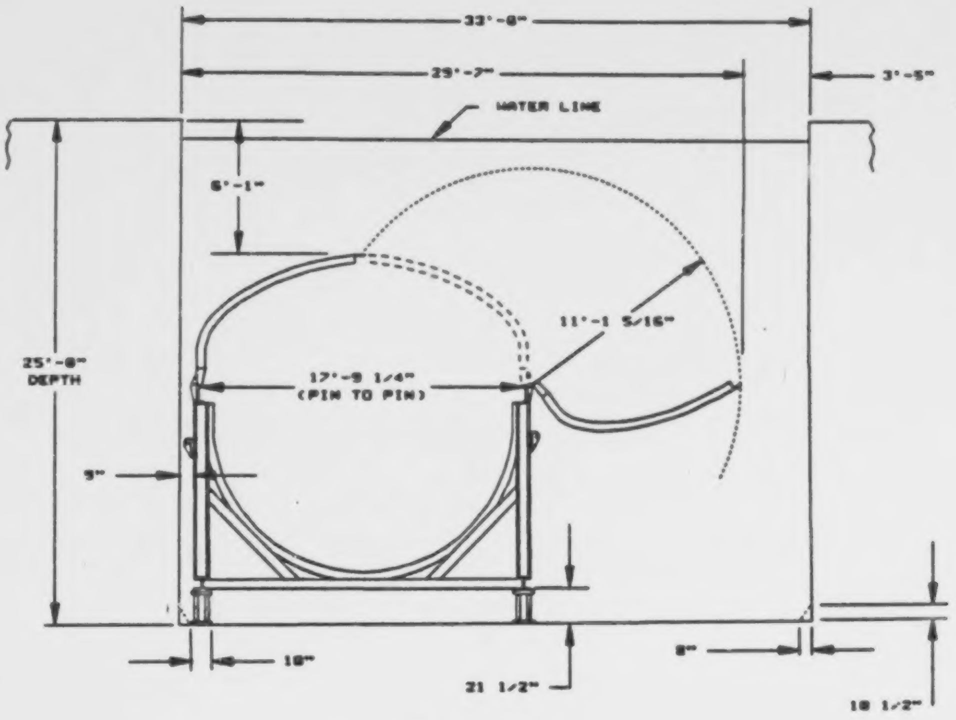
THE JSC WETF WAS DESIGNED TO SUPPORT STS ORBITER PAYLOAD BAY EVA OPERATIONS. EVA PART TASK TRAINING AND CREWMAN ORIENTATION ARE COMPROMISED DUE TO FACILITY SIZE LIMITATION.

EXAMPLES:

THE STS HUBBLE SPACE TELESCOPE EVA TASKS

ORBITER RMS MANIPULATOR FOOT RESTRAINT TASKS

SPACE STATION TRUSS ASSEMBLY ENGINEERING EVALUATION

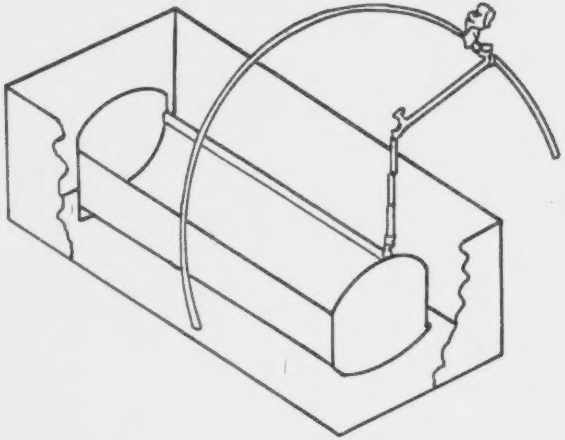

33'-0"
29'-7"
3'-5"
WATER LINE
6'-1"
25'-0"
DEPTH
11'-1 5/16"
17'-9 1/4"
(PIN TO PIN)
9"
10"
21 1/2"
8"
10 1/2"

SECTION SHOWING
ORBITER NEUTRAL BOUYANCY TRAINER
IN PLACE

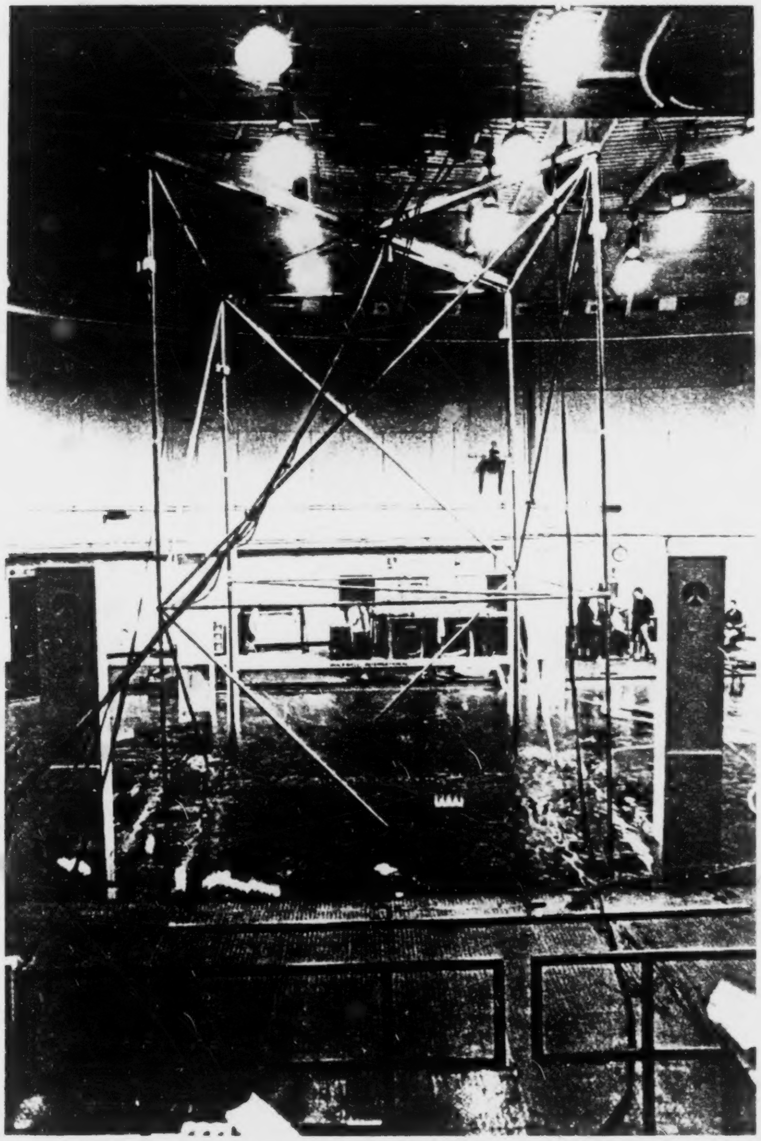
WEIGHTLESS ENVIRONMENT TRAINING FACILITY

JOHNSON SPACE CENTER

STS ORBITER PAYLOAD/SATELLITE SERVICING
EVA TASKS UTILIZING THE RMS AND THE
MFR ARE EXTREMELY LIMITED AT THE WETF.



WETF RMS LIMITATIONS



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MAN-SYSTEMS DIVISION

SPACE STATION EVA CRITICALITY

- ON PAST PROGRAMS, THE SUCCESS OF THE EVA DID NOT DETERMINE THE FUTURE OF THE PROGRAM.
- FOR SPACE STATION, PARTICULARLY THE EARLY FLIGHTS, EVA FAILURE IS UNACCEPTABLE.

SPACE STATION ASSEMBLY CRITICALITY

SPACE STATION ON ORBIT ASSEMBLY IS CRITICAL

- PROGRAM BASED UPON SUCCESSFUL EVA AT EACH ASSEMBLY FLIGHT
- EVA TIMELINES ARE VERY CRITICAL DUE TO LIMITED STS RESOURCES
- VERY LIMITED SPACE STATION SPARES IN THE PROGRAM
- ADEQUATE NEUTRAL BUOYANCY SIMULATION WILL GREATLY INCREASE THE PROBABILITY OF SUCCESSFUL ON-ORBIT EVA

SPACE STATION OPERATIONAL REQUIREMENTS

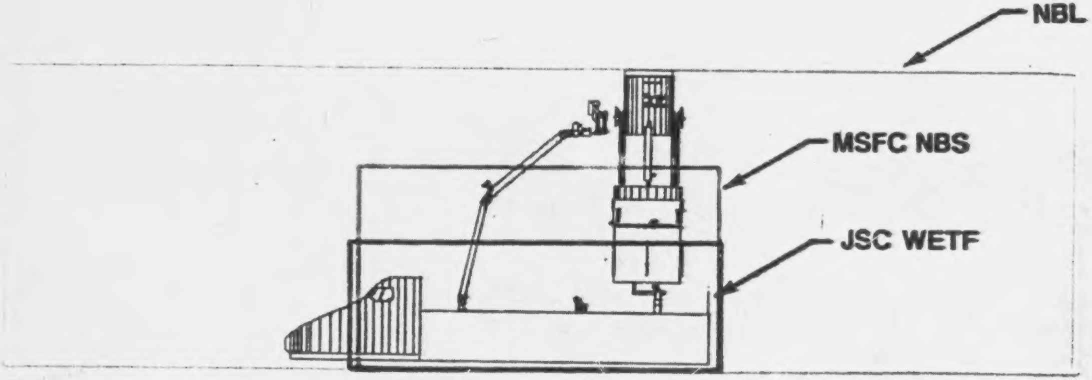
THE FOLLOWING REQUIRES DEVELOPMENT, VERIFICATION, EVA ASTRONAUT TRAINING, AND REAL TIME MISSION SUPPORT

- MAINTENANCE
- PAYLOAD SERVICING
- STATION GROWTH AND CHANGES

NBL STS REQUIREMENTS

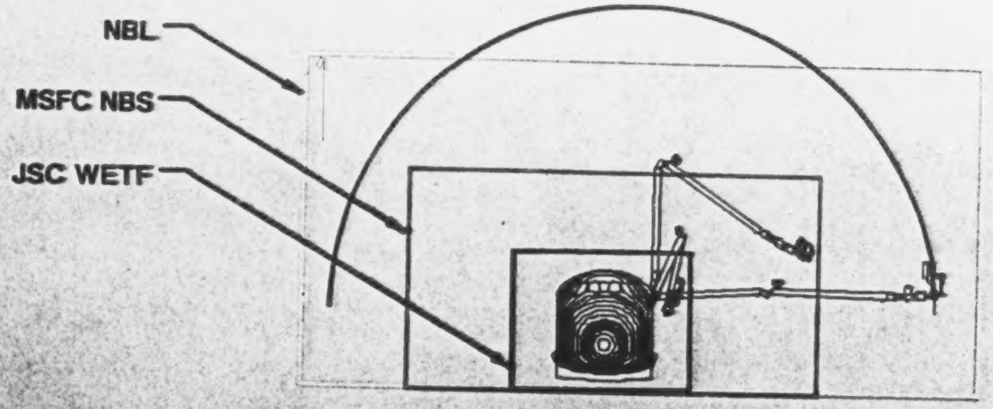
- CREW TRAINING FOR SPACE STATION ASSEMBLY FLIGHTS
- STS SATELLITE SERVICING; EXAMPLE, SPACE TELESCOPE AND GAMMA RAY OBSERVATORY SERVICING MISSIONS
- STS MISSIONS WHICH INVOLVE RMS MANIPULATOR FOOT RESTRAINT (MFR) OPERATIONS
- STS MISSIONS WHICH SUPPORT SPACE STATION AS A TEST BED

SPACE TELESCOPE IN JSC WETF, MSFC NBS, AND NBL


NBL
MSFC NBS
JSC WETF

SIDE VIEW

RMS/MFR MANEUVERS


NBL
MSFC NBS
JSC WETF

FRONT VIEW

SPACE STATION NBL REQUIREMENTS

ASSEMBLY

- VALIDATE EVA SYSTEMS, CREW EQUIPMENT AND STATION ASSEMBLY DESIGNS
- PROVIDE REAL TIME SUPPORT FOR MAINTENANCE, REPAIR, AND INSPECTION
- VALIDATE EVA CREW INTERFACES AND OPERATIONS WITH THE MSC AND FTS
- PROVIDE CREW TRAINING TO SUPPORT STATION ASSEMBLY
- CONTINGENCY CAPABILITY

OPERATIONS

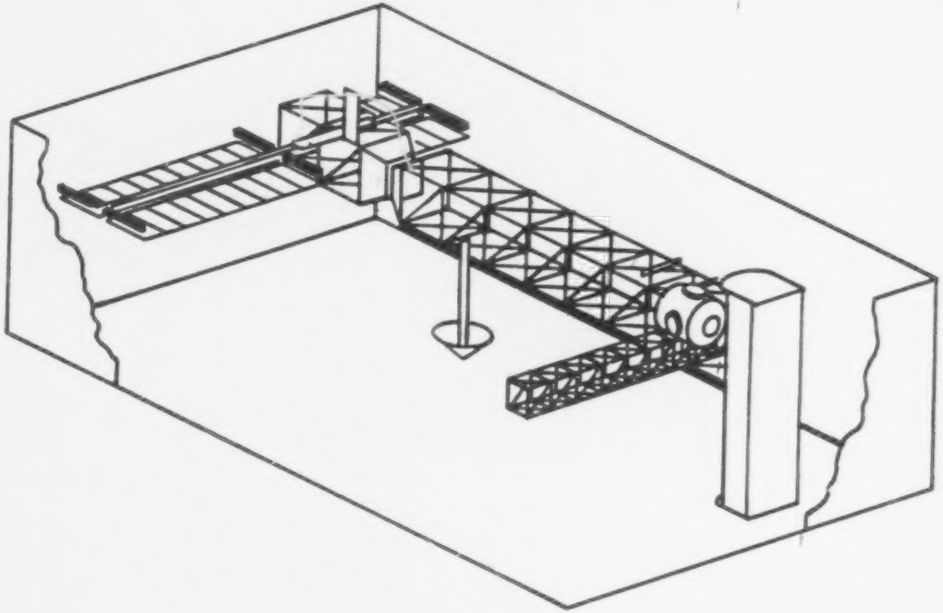
DEVELOP AND VALIDATE DESIGN OF GROWTH FACILITIES. FOR EXAMPLE:

- SATELLITE SERVICING FACILITY
- SOLAR DYNAMICS POWER GENERATION SYSTEM
- EXPERIMENT/PAYLOAD ACCESSIBILITY AND MOUNTING PROVISIONS
- STORAGE AND DEPLOYMENT OF LARGE (STS/ELV) PAYLOADS REQUIRING EVA OPERATIONS

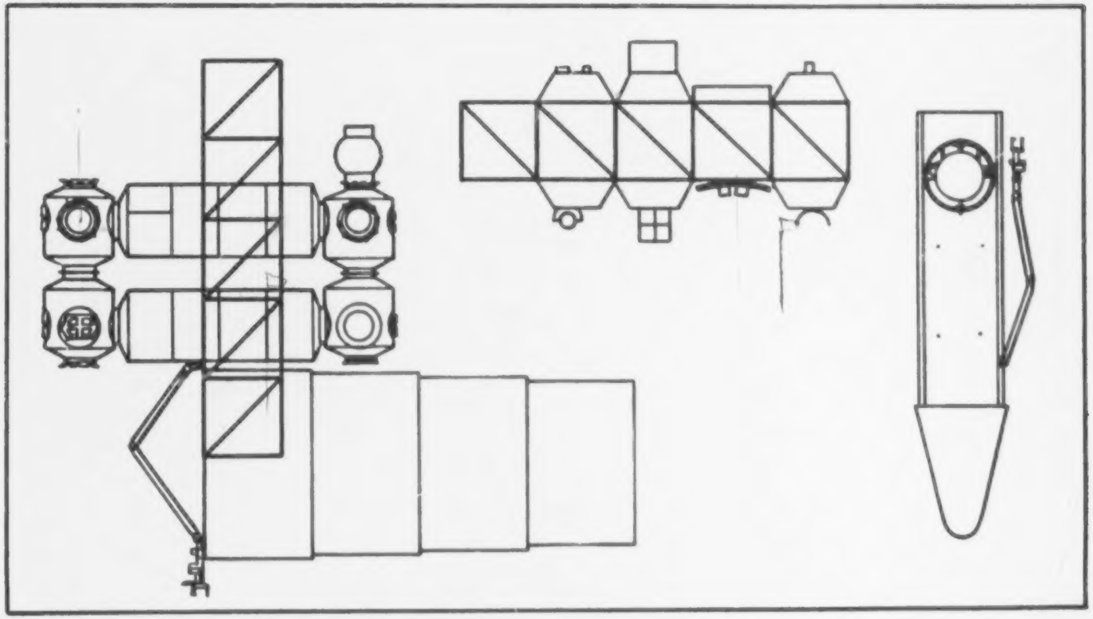
PROVIDE REAL TIME MISSION SUPPORT TO SPACE STATION MAINTENANCE, REPAIR, INSPECTION, AND CONTINGENCIES

PROVIDE CREW TRAINING FOR ROUTINE AND UNIQUE EVA OPERATIONS AND FOR NEW LARGE STRUCTURES, SPACECRAFT AND SATELLITES

CETF ASSEMBLY FLIGHT 1 IN NBL

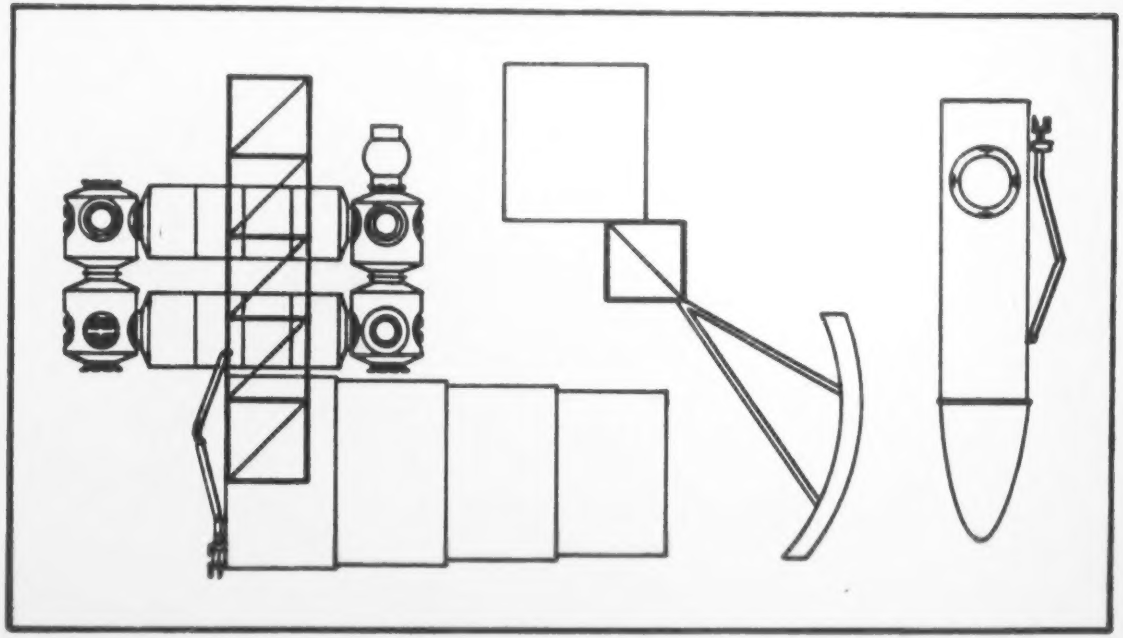


225 X 125 4 WORK STATIONS



NBL TOP VIEW

225 X 125   4 WORK STATIONS



NBL TOP VIEW

FUTURE PROGRAM CONSIDERATIONS

- SPACE STATION; SERVICING FACILITY, POWER MODULES, LARGE ANTENNAS, GROWTH
- STRATEGIC DEFENSE INITIATIVE (SDI)
- STS SATELLITE SERVICING MISSIONS
- SPACE PLATFORMS (INDUSTRIAL SPACE FACILITIES, ESA/COLUMBUS SPACE PLATFORM, U.S. SPACE PLATFORMS)
- LARGE STRUCTURES ASSEMBLIES
- SOLAR SYSTEM EXPLORATION VEHICLES

SOURCES:

- SPACE TRANSPORTATION ARCHITECTURE STUDY (STAS)
- SPACE ASSEMBLY, MAINTENANCE, AND SERVICING STUDY (SAMS)
- CRITICAL EVALUATION TASK FORCE (CETF)

NEUTRAL BUOYANCY FACILITY ACTIVITY LOADING

- EXISTING FACILITIES (WETF, NBS, UWTF) WILL CONTINUE TO BE UTILIZED TO CAPACITY WITH PRESENT PROGRAM REQUIREMENTS

  WETF - STS ORBITER PAYLOAD BAY OPERATIONS, PAYLOAD BAY DOOR CONTINGENCY, AND CREW ESCAPE SYSTEM TRAINING AND DEVELOPMENT

  NBS - STS PAYLOADS, STATION AND FUTURE PROGRAM DEVELOPMENT

  UWTF - COMMERCIAL AND USAF DEVELOPMENT TASKS

- OPERATIONAL NBL IN MID 1992 IS REQUIRED FOR STS, STATION AND FUTURE PROGRAMS FOR EVA DEVELOPMENT AND ASTRONAUT TRAINING
  - SUPPORT STATION EVA HARDWARE VALIDATION, PROCEDURE DEVELOPMENT AND ASTRONAUT TRAINING FOR FIRST ELEMENT LAUNCH
  - SUPPORT POST CDR HARDWARE DEVELOPMENT AND EVA ASTRONAUT TRAINING
  - SUPPORT FOR STS LARGE PAYLOADS/SATELLITE SERVICING AND STATION OPERATIONS
- CETF EVA REQUIREMENTS EXCEED THE NBL WORKLOAD CAPABILITY IN THE OUT YEARS AND REQUIRES FURTHER EVALUATION

SIZING OF THE NBL

NBL SHOULD ACCOMMODATE STS, SPACE STATION, AND FUTURE PROGRAMS

LENGTH	225 FEET
WIDTH	125 FEET
DEPTH	60 FEET

NBL LENGTH SIZING

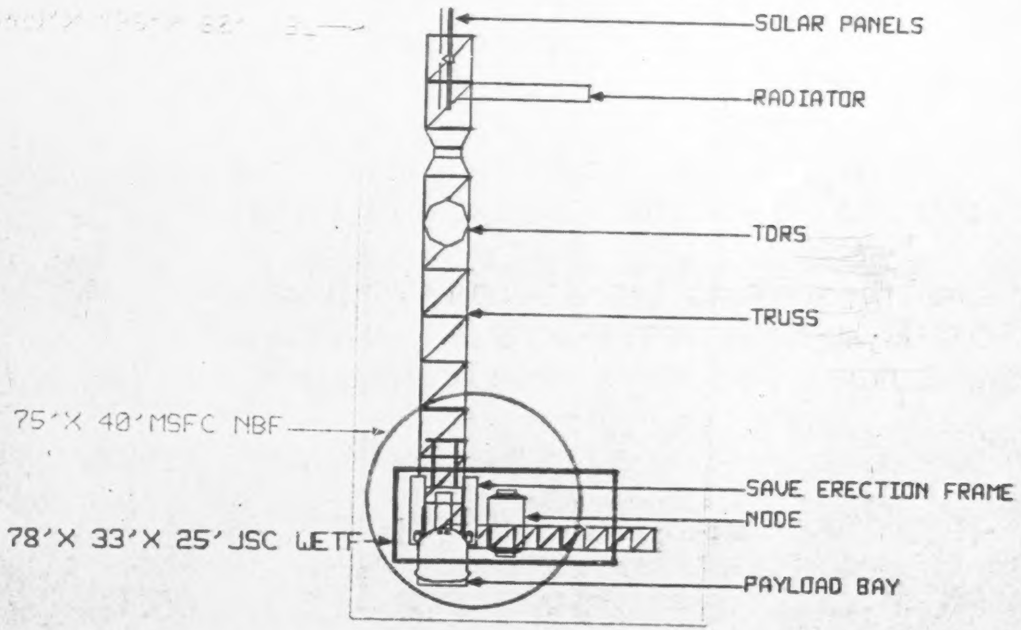
A LENGTH OF 225 FEET IS DRIVEN BY:

- ASSEMBLY FLIGHT 1 CONFIGURATION: ORBITER PAYLOAD BAY, ERECTION FIXTURE, RESOURCE NODE, ELEVEN BAYS OF TRUSS, ALPHA JOINT, AND THE SOLAR POWER MODULE/RADIATORS

- CAPABILITY FOR MULTIPLE GENERIC WORKSTATIONS AND DUAL SIMULTANEOUS NBL OPERATIONS

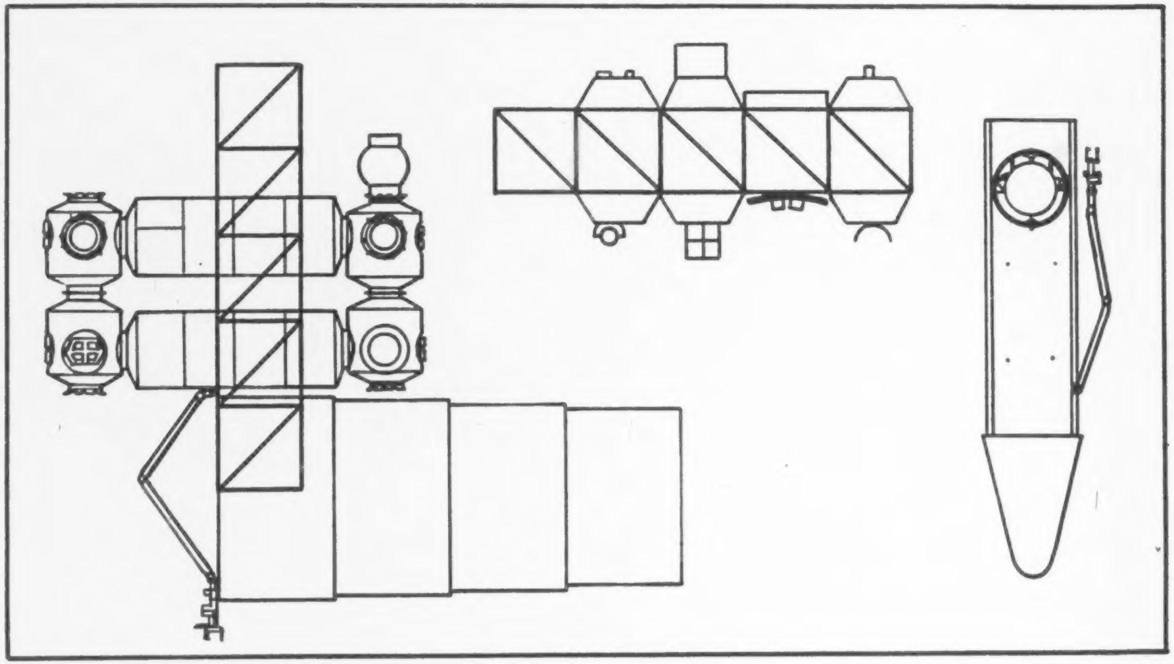
- OPERATIONAL CLEARANCE OF FIVE FEET MINIMUM BETWEEN MOCKUP AND POOL WALL

CETF ASSEMBLY FLIGHT 1 IN NBL


SOLAR PANELS
RADIATOR
TDRS
TRUSS
75'X 40'MSFC NBF
SAVE ERECTION FRAME
NODE
78'X 33'X 25'JSC WETF
PAYLOAD BAY

TOP VIEW

225 X 125 4 WORK STATIONS



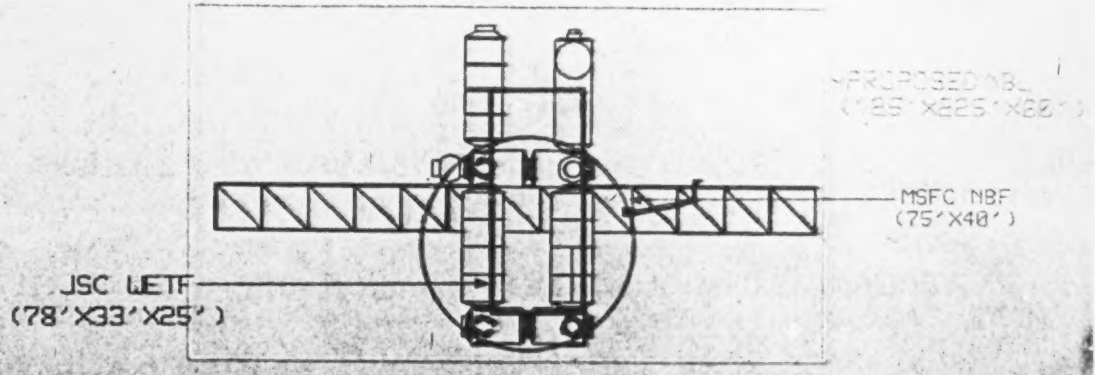
NBL TOP VIEW

NBL WIDTH SIZING

THE WIDTH OF 125 FEET IS DRIVEN BY:

- THE SPACE STATION MODULE CLUSTER
- THE OPERATION OF THE STS RMS/SPACE STATION MSC
- THERE ARE FUTURE SPACE PAYLOADS WHICH ARE VERY LARGE AND HAVE A REQUIRED CONTINGENCY EVA CAPABILITY; EXAMPLE: THE MILLIMETER WAVE ANTENNA WHICH IS 100 FEET IN DIAMETER

A SPACE STATION MODULE CONFIGURATION IN NBL

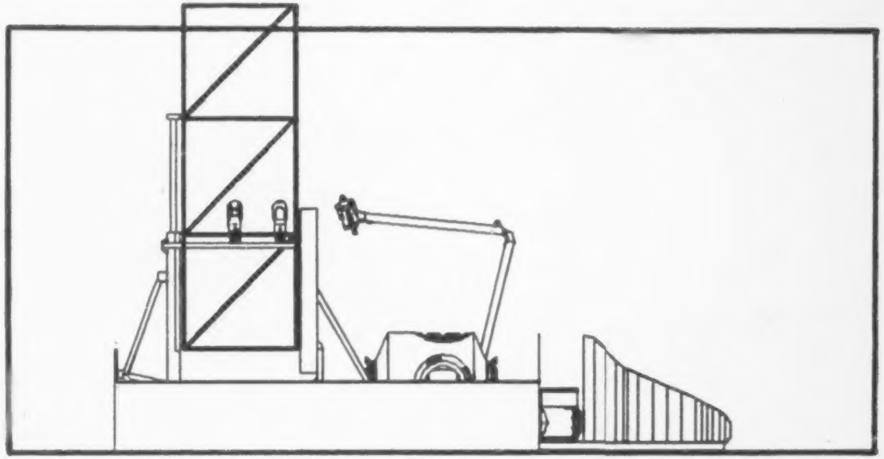

PROPOSED NBL
(125'X225'X60')
MSFC NBF
(75'X40')
JSC WETF
(78'X33'X25')

TOP VIEW

NBL DEPTH SIZING

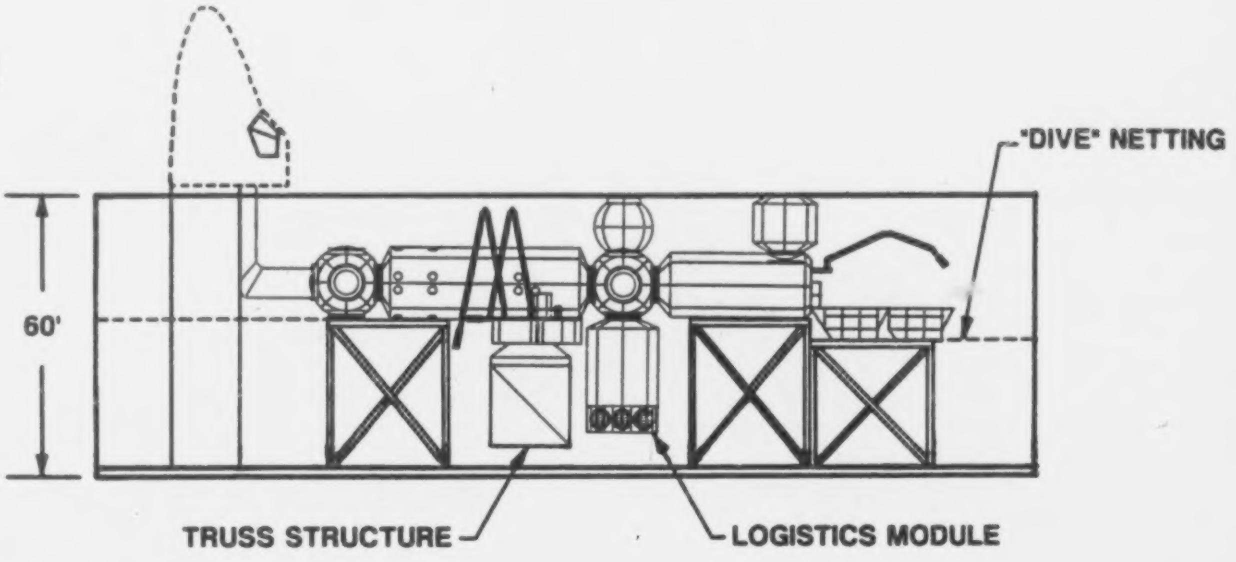
THE DEPTH IS 60 FEET AND IS DRIVEN AND CONSTRAINED BY SEVERAL FACTORS:

- SPACE STATION TRUSS ASSEMBLY, TWO BAYS, IN THE VERTICAL WITH THE ORBITER PAYLOAD BAY, RMS AND WORK STATION
- STS SPACE TELESCOPE IN THE CORRECT POSITION WITH THE ORBITER PAYLOAD BAY, SERVICING PALLETS, AND RMS
- SUITABLE DEPTH FOR ORBITER RMS/SPACE STATION MSC OPERATIONS
- PROVIDES THE HIGHLY DESIRABLE VERTICAL ORIENTATION OF THE EVA CREWMAN'S WORKSITE IN THE NEUTRAL BUOYANCY SIMULATIONS
- GREATER DEPTH WILL RESULT IN EXTENSIVE DECOMPRESSION TIME FOR THE SUITED SUBJECT



TRUSS ASSEMBLY IN NBL

A SPACE STATION CONFIGURATION IN NBL


"DIVE" NETTING
60'
TRUSS STRUCTURE
LOGISTICS MODULE

SIDE VIEW

DIVING OPERATIONS SAFETY REVIEW

THE PROPOSED NBL DIVING OPERATION WAS REVIEWED WITH FOUR NATIONALLY KNOWN ACADEMIC AND TECHNICAL DIVING PHYSIOLOGY EXPERTS ON AUGUST 11 AND 12, 1987

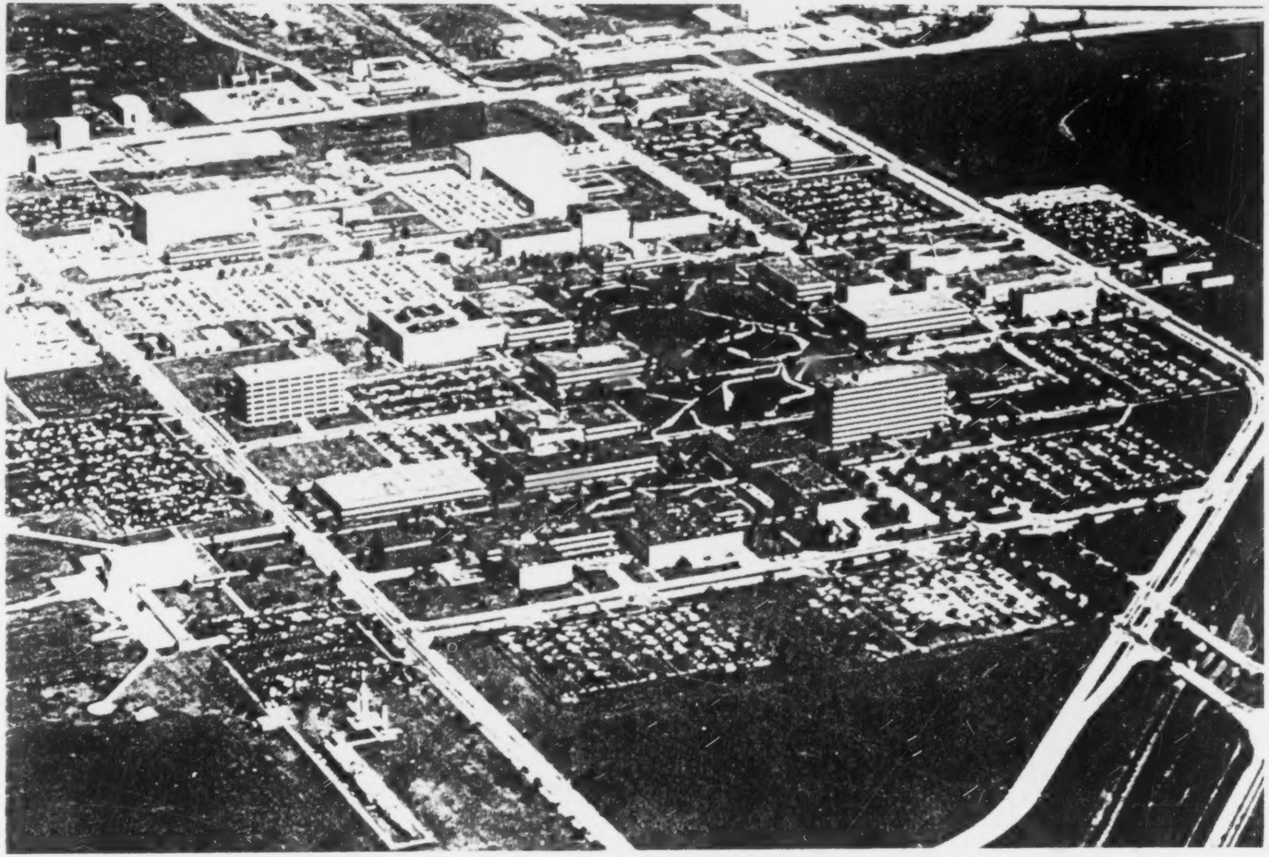
• GLEN H. EGSTROM, PH.D.	PROFESSOR OF KINESIOLOGY, UNIVERSITY OF CALIFORNIA LOS ANGELES
• JAMES R. STEWART	DIVING OFFICER, SCRIPPS INSTITUTE OF OCEANOGRAPHY, UNIVERSITY OF CALIFORNIA
• RICHARD D. VANN, PH.D.	ASSISTANT MEDICAL RESIDENT PROFESSOR DUKE UNIVERSITY MEDICAL CENTER
• PETER B. BENNETT, PH.D. & D. SC	ASSOCIATE PROFESSOR, DEPARTMENT OF PHYSIOLOGY DUKE UNIVERSITY MEDICAL CENTER DIRECTOR, F. G. HALL ENVIRONMENTAL LABORATORY

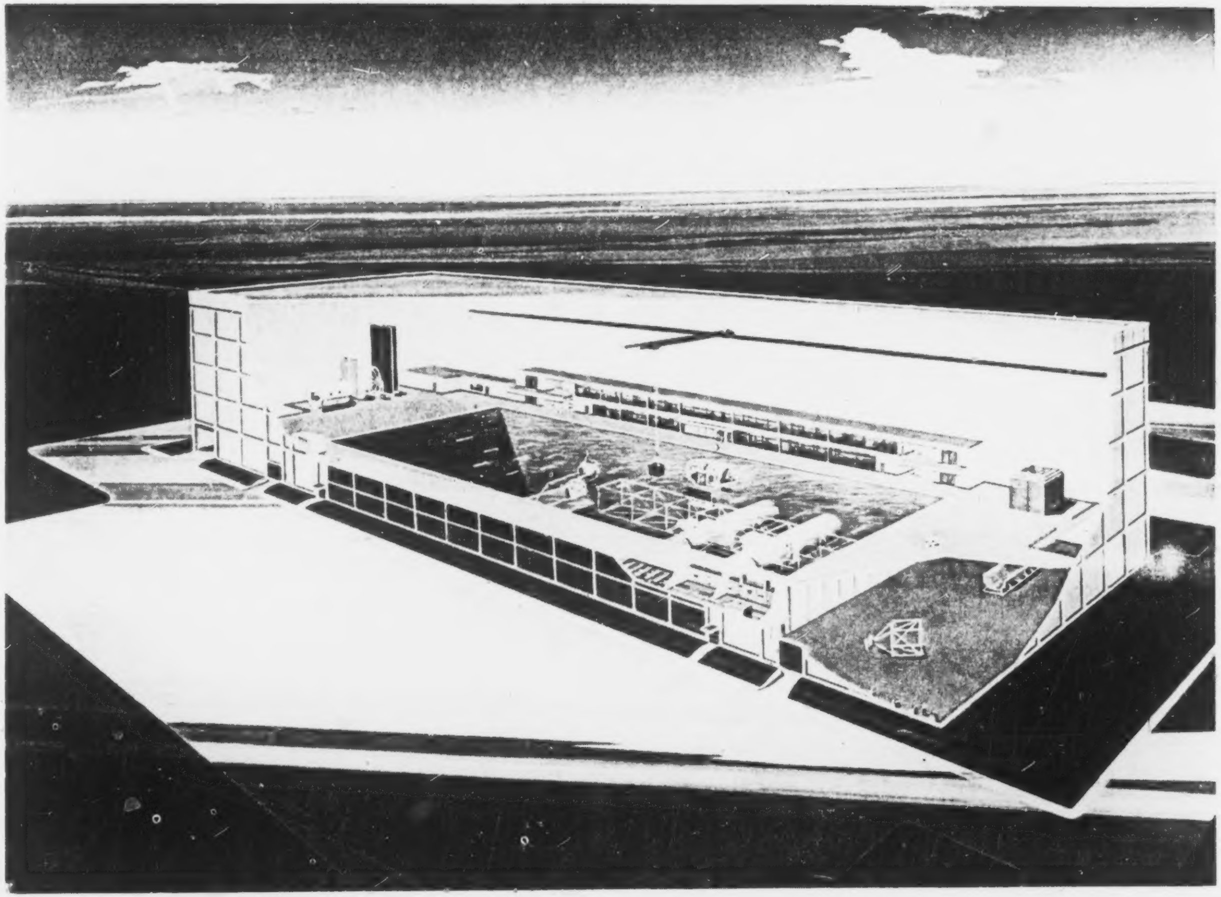
DIVING OPERATIONS SAFETY

- THERE ARE NO UNUSUAL DIVING PHYSIOLOGY/MEDICAL PROBLEMS WITH SUITED NEUTRAL BUOYANCY SIMULATIONS AT THE 60 FOOT DEPTH
- WILL OPERATE AT THE SHALLOWEST DEPTH FEASIBLE TO MINIMIZE THE DECOMPRESSION
- SPECIAL "CUSTOM MADE" DECOMPRESSION TABLES WILL BE DEVELOPED CONSISTENT WITH THE LATEST TECHNOLOGY AND TESTED.
- WILL MEET THE AGENCY STANDARDS FOR NEUTRAL BUOYANCY SIMULATIONS
- NBL FEATURES WHICH WILL FURTHER ENHANCE THE DIVING SAFETY:
  - THE USE OF 100% 0_2 BY MASK WILL BE USED TO MINIMIZE DECOMPRESSION TIME
  - UTILIZATION OF ADJUSTABLE FLOORING/NETTING TO PRECLUDE UNSCHEDULED DEEP DIVES
  - MAN LOCK AT 30 FOOT DEPTH WHICH INCLUDES A DECOMPRESSION ROOM AND A HYPERBARIC CHAMBER
  - DIVE MASTER CONCEPT WITH TIME AND DEPTH TRANSPONDER READOUT AT POOL SIDE

NBL CONSTRUCTION

- DESIGN AND COST STUDY OF THE POOL COMPLETED BY CRS SIRRINE
- CONTEMPLATED POOL DESIGN IS 30 FEET BELOW GROUND LEVEL, 30 FEET ABOVE
- BUILDING FOOTPRINT AREA 68,400 SQUARE FEET; BUILDING HEIGHT APPROXIMATELY 100 FEET
- TWO TEN TON CRANES, 45 FOOT HOOK HEIGHT
- INCLUDES ROOM TO HOUSE SUPPORT PERSONNEL, EMERGENCY MEDICAL TREATMENT AREA, MOCKUP BUILD UP AREA, AND TOUR ACCOMMODATIONS

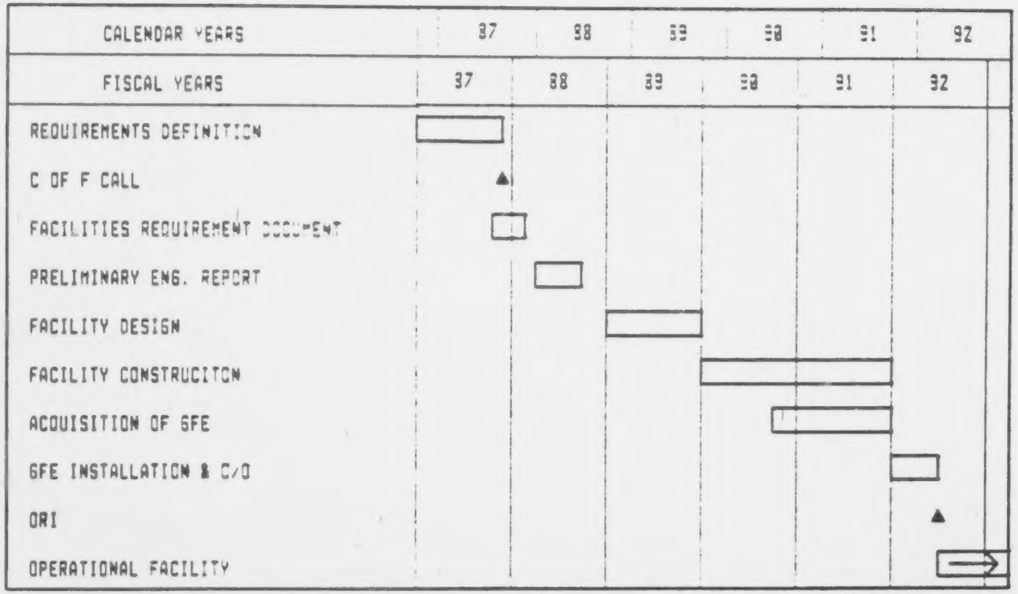


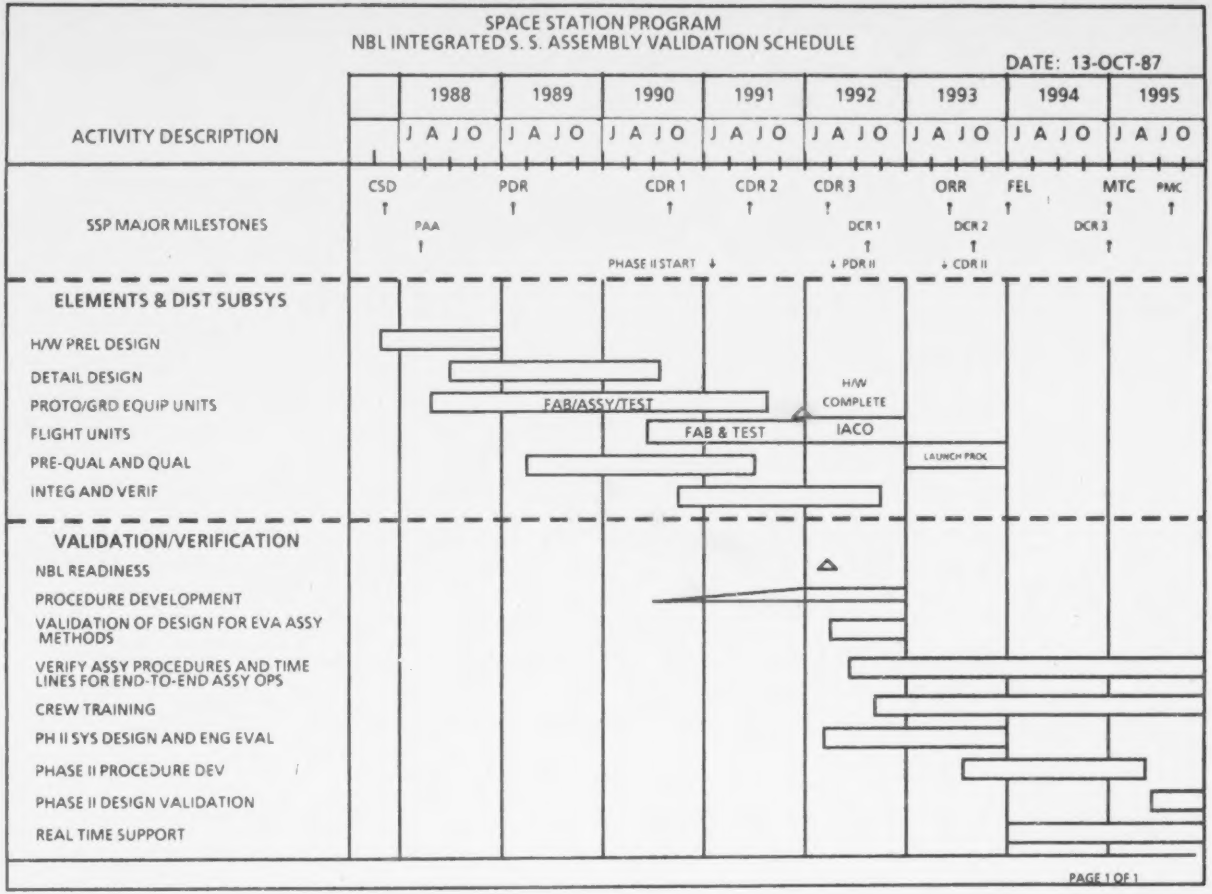


NASA LYNDON B. JOHNSON SPACE CENTER

MAN-SYSTEMS DIVISION

NBL FACILITY DEVELOPMENT SCHEDULE




SPACE STATION PROGRAM
NBL INTEGRATED S. S. ASSEMBLY VALIDATION SCHEDULE
DATE: 13-OCT-87
ACTIVITY DESCRIPTION
1988
1989
1990
1991
1992
1993
1994
1995
J A J O
SSP MAJOR MILESTONES
CSD
PAA
PDR
CDR 1
PHASE II START
CDR 2
CDR 3
DCR 1
PDR II
ORR
DCR 2
CDR II
FEL
DCR 3
MTC
PMC
ELEMENTS & DIST SUBSYS
H/W PREL DESIGN
DETAIL DESIGN
PROTO/GRD EQUIP UNITS
FAB/ASSY/TEST
H/W COMPLETE
FLIGHT UNITS
FAB & TEST
IACO
LAUNCH PROC
PRE-QUAL AND QUAL
INTEG AND VERIF
VALIDATION/VERIFICATION
NBL READINESS
PROCEDURE DEVELOPMENT
VALIDATION OF DESIGN FOR EVA ASSY METHODS
VERIFY ASSY PROCEDURES AND TIME LINES FOR END-TO-END ASSY OPS
CREW TRAINING
PH II SYS DESIGN AND ENG EVAL
PHASE II PROCEDURE DEV
PHASE II DESIGN VALIDATION
REAL TIME SUPPORT
PAGE 1 OF 1

- THE ESTIMATES FOR THE NEUTRAL BUOYANCY MOCKUP HARDWARE FOR SPACE STATION IS IN THE BUDGET AND HAS BEEN REVIEWED AS PART OF THE POP 87-2 BUDGET EXCERCISE. THIS FUNDING WILL SUPPORT THE SPACE STATION NEUTRAL BUOYANCY HARDWARE REQUIRED IN THE NBL.

FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	
200	300	400	1,500	1,300	1,300	1,200	1,200	$K

- IN ADDITION, THE MANPOWER BUDGET TO OPERATE THE NBL IS:

	FY92	FY93	FY94	FY95	FY96	
STAFFING REQUIRED FOR ONE TWO-SUITED EXCERCISE PER DAY IN THE NBL	29	29	29	29	29	
IN BUDGET FOR WETF 2ND SHIFT	16	16	16	16	16	MYE
NET MYE INCREASE	13	13	13	13	13	MYE
NET INCREASE TO BUDGET	767	793	828	866	905	$K

- THE ANNUAL NBL UTILITY COST IS ESTIMATED TO BE IN THE $750K RANGE. ENERGY SAVINGS SUGGESTIONS WHICH WOULD REDUCE THIS COST ITEM HAVE BEEN RECEIVED.
- FACILITY OUTFITTING (EQUIPMENT) BUDGET IS $750K IN FY 91.

NBL OUTFITTING (EQUIPMENT) BUDGET

	$K
SCUBA GEAR	30
TV SYSTEM	150
LOCKER ROOM	20
RIGGING	20
DIVE MONITORING SYSTEM	150
SHOP TOOLS	30
HAND TOOLS	20
CONSOLES, UMBILICALS AND COMPUTER	200
FORKLIFTS	50
COMMUNICATION SYSTEM	50
SPARE PARTS	30
TOTAL	750

NBL CONCLUSION

- THE NBL SHOULD BE BUILT AT JSC AT THIS TIME TO SUPPORT THE STS, SPACE STATION, AND FUTURE PROGRAMS WELL INTO THE NEXT CENTURY.
- THE NBL IS A REQUIRED "TOOL" FOR THE AGENCY TO DO ITS ASSIGNED TASK.
- INCLUDE THE NBL AS A HIGH PRIORITY ITEM IN THE FY87 (C OF F) CALL AS A FY 90-91 CONSTRUCTION PROJECT.

Mr. **Nelson**. Okay. Now, Dr. Fletcher, the President under the existing appropriation law has until May the 15th to act on the Space Station commitment. Specifically, $515 million are fenced until the President says go. Now we don't expect any surprises with this President since he has committed in concrete to this point. So, since we're not expecting any surprises, why don't we go on and get that out of the way so that we can get all of our contractors revved up and pursuing this thing with vigor instead of hanging around till May the 15th?

Dr. **Fletcher**. I think I understand your question. Why don't we spend the money as if that's going to be approved, which would be at a higher rate. I think there is always a risk when you do that, and I think you're telling us to take the risk.

Mr. **Nelson**. Well, no. What I'm saying is, why don't you go on and get the President to announce his intention—I mean, his intention is already made clear—so that you all could act on the basis of that.

Dr. **Fletcher**. Oh. I, I misunderstood the question, Mr. Chairman. I'd be surprised—but I'm always surprised—if the President didn't say something about that on February 9th, what his intentions were.

Mr. **Nelson**. Okay. If that's the case, then how do you implement it? Can you do it just as you——

Dr. **Fletcher**. Well, that's what I was——

Mr. **Nelson** [continuing]. as you indicated?

Dr. **Fletcher** [continuing]. I was not sure of.

Can we, Tommy?

Mr. **Campbell**. I'm not certain that we can, Chairman Nelson. I believe the law holds it until the 15th of May. That's my interpretation.

Mr. **Nelson**. All right. Assuming that the law does—now there's always the possibility that we could make some modifications with the Appropriations Committee. But assuming that we couldn't make any modifications, the law does, are there not decisions that you can make predicated on the fact that the fence is coming down May the 15th when the President has already indicated his intention?

Dr. **Fletcher**. Mr. Chairman, I think we're doing that. We're assuming that that decision will be positive and we're making decisions as if we're going right on. The only thing is we, as I understand it, we can't spend the money beyond a certain level.

Mr. **Campbell**. That's correct. We conserved as much as we could from the prior year so that the buildup will be in an orderly fashion. We're planning to move out very smart on the 15th of May, and I expect by the end of the year the rate will be in the order per month of about 120 million.

Mr. **Nelson**. Are there any savings or efficiencies that you could get out of the spending over the rest of the year if that date of May the 15th were accelerated earlier?

Dr. **Fletcher**. I think I'd like Mr. Odom to answer that. He's here. But it's, my intuitive reply would be, sure. There's a lot of things we could do earlier and we'd have a little bit more margin in terms of schedule.

But, go ahead.

Mr. Odom. Mr. Chairman, I think you're on—obviously, you're on the right track in that, I think, to say there would be savings, I would not want to sign up to that. I do think there would be significant efficiencies gained in a much more gradual buildup that took us literally from this point or as early before May the 15th as is possible and continue a much more efficient buildup in the ramp through the end of this year, as opposed to staying flat, which is kind of basically where we've been since last June and then doing a very rapid buildup from May the 15th through September.

So I think there's a lot of efficiencies in the rate at which we can bring on the major subs, and also the long lead procurements that we have been holding back on, if we can get those and the materials coming into our major contractors much more efficiently. And also the posture is better for them to build up going on in to the next fiscal year.

Mr. Nelson. Does any of the staff have any follow-up on that, that you want to get into any details?

[No response.]

All right. Now there's a part of this budget that I don't like, and that is, that you have fallen below 20 percent of the NASA budget on science. Talk to us about that.

Dr. Fletcher. Well, we never committed, except to over a period of time to keep the science and applications budget at 20 percent of the 2 line items that you mentioned. However, it's not bad. It's, as I recall, 18.5 percent, something like that. It's pretty close to 20 percent.

What happens, Mr. Chairman, is that you, the Congress, whack away at our budget, so what we present in the beginning doesn't turn out to be what comes out at the end. Last year, we started out with less than 20 percent and we ended up with 21½ percent. So you can't keep it exactly on the 20 percent line, and we're pretty close to that and we have been for some years.

Mr. Nelson. It's a downward trend. That's the last 3 years. You can see it's downward. It's now below the 20 percent.

Dr. Fletcher. Well, wait a minute. If you take last year's budget, as I understand it, it was 21-point-something percent what came out of Congress.

Mr. Myers. And the orbiter was that dip.

Dr. Fletcher. You're talking about the dip, Mr. Chairman?

Mr. Myers. Full funding for the orbiter.

Mr. Campbell. Full funding.

Mr. Nelson. No, I'm talking about—look at the last part of that line. You see it's downward. That's the last 3 years.

Dr. Fletcher. The last 3 years?

Mr. Nelson. That's the science part of the NASA budget. Right there.

Dr. Fletcher. I can't read the coordinate from here.

Mr. Nelson. Well, we'll, we'll, we'll——

Dr. Fletcher. But believe me, Mr. Chairman, last year it was 2 percent. Take—make the calculation yourself.

Mr. Nelson. Yes. Yes, this year it's 18.3.

Dr. Fletcher. But that's the——

Mr. Nelson. The year before that it was 22.2. That's the downward trend I'm talking about.

Dr. Fletcher. No. No. I still want to make my point here. You, first of all, you can't keep it exactly 20 percent, but what goes in as the President's budget isn't what comes out of the Congress, and so you have to look at not the President's budget year by year but what comes out of Congress year and year, and I think that has consistently been above 20 percent for—since I've been here, anyway.

Mr. Nelson. Why don't you share with us what percentage reduction in the science budget occurred from the time that you submitted your budget request to OMB and then when it came out of the meat grinder that you have presented to us today?

Dr. Fletcher. We'll have to provide it for the record, but it, to a first approximation, we cut the science budget proportionate to the rest of the cuts that we received from OMB and the President.

Mr. Nelson. Well, today your science portion of the budget requested is 18.3, in the fiscal year 1990 budget that you have submitted to us. What percentage of your budget that you submitted to OMB was the science budget?

Mr. Campbell. It was about the same, Mr. Chairman.

Mr. Nelson. About the same.

Mr. Campbell. Yes.

Mr. Nelson. Can you give us a specific figure?

Mr. Campbell. It's a little over 18 percent.

Mr. Nelson. A little over 18 percent.

Is—by the way, what we've been told, is it correct, that you went to OMB with about a billion dollars more in requests?

Dr. Fletcher. That's correct, Mr. Chairman.

Mr. Nelson. In the cuts that occurred since OMB, from OMB—in the cuts that occurred in OMB, how does the science cut compare to the Space Station cut?

Dr. Fletcher. Oh.

Mr. Campbell. It was greater than the Space Station cut in total because the OMB, largely I think because the OMB continues to remove the ACTS program, Mr. Chairman, and that was in the order of $61 million for the baseline program and we had an—in addition, we had about $6.5 million in for government funding of the experiment programs.

Mr. Nelson. All right. Can you——

Mr. Campbell. The total was about $140, I think, and almost half of that was for the ACTS previously.

Mr. Nelson. Can you give us as percentages the answer to that?

Mr. Campbell. For the record.

Mr. Fletcher. We can supply it for the record; yes.

[The information follows:]

The FY 1990 request for OSSA to OMB was $2136.2 million; the request for OSSA to Congress was $1995.3 million. This is a 6.6 percent reduction.

Mr. Nelson. All right. Dr. Fletcher, if you want to answer this or turn to anybody else. Tell us how bad these cracks are in the engine, and now that we're looking at mid-March, I'm assuming there's a possibility this mission is going to be cancelled altogether if it gets delayed beyond that, because you've got that window on Magellan that you've got to launch. What's the story?

Dr. FLETCHER. Mr. Chairman, I'll do the best I can, and I have been involved thoroughly. Not as expert as Mr. Myers and Mr. Abbey, but probably I can take out the technical jargon and explain it just as well as they can.

We had a situation on STS-27 in which the race that the bearings were in for the turbopump on the hydrogen side, I think—oxygen side, which we, when we pulled it apart and examined it had a major crack in it. And we had noticed during the flight that the vibrations from the engines were more severe than nominal, and it's now been pretty definitely shown that the crack probably did contribute to those excess vibrations. No harm was done, but nevertheless, a crack is something you don't want to live with.

So we went back and asked ourselves what could have caused that crack, and we found—and a lot of work was done on this; very careful and good work, by the way—that there had been a change in the procedures by which the turbopump was together, in a way which a water, water from the atmosphere or wherever, was allowed to be trapped inside that bearing race, and that's enclosed later and if the water isn't taken out before it's put together it might cause some what we call stress corrosion, which is rust under some kind of stress, if you like.

And it did look as if that was the cause of the crack. That the combination of the stress that was on that bearing race plus some water that had gotten into that improperly caused the crack, and also caused discoloration on some of the tracks that we examined. In fact, it was traced to a change in procedure when they moved from one facility to another. And in looking, I think it was 7 of the pumps that came out of that new facility, there was suspicion that all 7 of them may have been affected by this procedure, 3 of which were scheduled to go on the STS-29, I guess is the next one.

It was kind of a difficult of choice. There was a lot of back-and-forth discussion because we've never—we've had that problem before, a long time ago, and it went away. This is the first time it's occurred since the early flights. After much discussion we decided that, heck, we're signed up to make this a safe shuttle and we should not take a chance of that sort. So the decision was made last night to go ahead and change all 3 engines on the pad. All 3—I'm sorry—all 3 turbopumps on the pad.

And, now what does that do to the schedule? And don't think we haven't looked at that backwards and forwards and sidewards.

Mr. NAGLE. Would the gentleman—Mr. Chairman, could I ask a question before we go into schedule on that question?

Mr. NELSON. Sure.

Mr. NAGLE. Were those pumps cracked before the launch, the last SST?

Dr. FLETCHER. As near as we can tell, we can't prove it, they were. One—there were 3 engines, of course, and only on one pump, but there was a crack on that pump and we believe that crack was there before launch.

Mr. NAGLE. And I think that the key——

Mr. FLETCHER. And it had passed the acceptance test.

Mr. NAGLE. The key, though, the key that keyed you that there was a problem was there was a—was it excessive vibrations during the early stages of the launch that keyed you to that?

Dr. FLETCHER. No, that wasn't the key, but that supported the argument that the crack had, indeed, occurred before the launch because that is what you would expect from a crack in the bearing races.

Mr. NAGLE. Now, in light of your statement today that the crack in the bearing race was, you know, last night you decided to not launch because it wasn't—obviously, didn't meet the margins of safety. It's a decision for which I applaud you. How was it that we came to launch that thing with a crack in the bearing race? I mean, why wasn't that discovered before we launched it?

Dr. FLETCHER. That's a much better question.

You want to try that?

Mr. NAGLE. Thank you. Well, it's nice to know I have one. [Laughter.]

Dr. FLETCHER. When I say good question, I mean it's a tough question.

Mr. ABBEY. The pumps are acceptance testing—acceptance tested, and the vibration level was not there and the crack was not there during acceptance testing. When we launched——

Mr. NAGLE. Well, I understand that, but it was there when you launched.

Mr. ABBEY. Well, we were not aware of that until after we launched and we saw the vibration levels then.

Mr. NAGLE. My question is, why not?

Mr. ABBEY. Well, there is no firing of the engine until we start the launch.

Mr. MYERS. After the acceptance test of a pump, up to the point of launch——

Mr. NAGLE. I understand the sequence. My question is what steps do you have—in light of the fact that you've now determined that that would be an unsafe launch condition, what steps do you have to determine prior to launch if those pumps are cracked?

Dr. FLETCHER. I think this is a tough question, and, George, I'm sorry. We should not give a short answer to that. Really what you're saying is that there was a failure in our procedures. That we should have been able to catch that crack before we launched.

Mr. NAGLE. That's a pejorative term. There is a problem, I would prefer.

Dr. FLETCHER. Yes. And what we try to do is catch as many of these faults as we can. We do acceptance tests; that is, we take the engines down, we test them on the stand, probably at the Mississippi facility, and then we ship them to the Cape to be launched. That seemed to be a fairly safe procedure. It did pass the acceptance test and yet it did have the problem on launch.

What we've got to do is figure out a way to—and we haven't done that yet—to make sure that nothing bad happened prior to launch in the way of a crack in that bearing race. I think we have not decided how to do that, but we have decided to go back and change those engines that could have had that kind of a crack in them, and we will launch with a new procedure. And still you're taking a chance that you may not have caught the problem.

Mr. NAGLE. My understanding of this is these cracks occurred while the shuttle, the pumps themselves, the motors, were idle, basically sitting under controlled environments, at room temperatures, under no stress—is that correct?

Dr. FLETCHER. No, wait. No, under stress.

Mr. MYERS. Under stress.

Dr. FLETCHER. That's the whole point. It's under stress so you can't tell when it's going to crack.

Mr. MYERS. That is how stress corrosion occurs.

Mr. ABBEY. And I'm not sure that the crack did not occur until after it was launched.

Mr. MYERS. We don't know that. All we do know——

Mr. NAGLE. I thought—I may be wrong on this, but I thought I saw a report that indicated, and I apologize if I'm wrong—and, Mr. Chairman, I'll get off this. But I thought I saw a report that indicated that most likely that crack occurred before launch.

Dr. FLETCHER. Well, it could have recurred——

Mr. NAGLE. Did I not see a report to that effect?

Dr. FLETCHER [continuing]. Early in the launch but it did—it was there during most of the launch phase. That's a fair statement.

Mr. MYERS. I think we would conclude that it probably happened—it's under stress; it had had water in it, the start of the corrosion; there has to be a contaminant present too—all 3 of those things create stress corrosion, and when it pops, it will just finally pop right on through the race and leave you with a crack.

When that happened, we know, we believe we know that it was after the acceptance test and before it was launched, but it could have been early in the launch phase.

Mr. NAGLE. But more likely it was before it was launched.

Mr. MYERS. Well, there is a longer—there is a longer time, certainly, for this stress corrosion to work at the material.

Mr. NAGLE. And we do not have—what you're saying, we have a problem in terms of testing or determining whether these things are cracked before we launch or not, obviously.

Mr. MYERS. So what we have to do is have procedures that exclude water from the race, and that's where I think we believe we had a problem during the process, when we changed that process. And having fixed that, we are taking those new pumps with new races, putting those pumps on the vehicle.

Mr. NAGLE. Um-hum. Dr. Hinners, did you want to add something? I thought—okay.

Dr. FLETCHER. I think it was Mr. Abbey that had something.

Mr. NAGLE. Yes.

Mr. ABBEY. I think in order to really pin down when the crack appeared we'd have to give you the data, show you the data when the vibration level was first picked up during the launch phase and that would probably identify when the crack occurred.

Mr. NAGLE. Unh-unh. Unh-unh. No. You don't want me to determine when the crack took place. I'm not qualified.

Mr. ABBEY. No. No, I mean we could show you the data or tell you what time——

Mr. NAGLE. It would be irrelevant. The point is that there is a more than likely than not chance that the shuttle was launched with a crack in a critical part. Is that not true? More likely than not?

Dr. FLETCHER. I think that's a safe statement, Mr. Nagle, although we can't really pin it down. It's also quite possible that the launch itself, when you start up the engine, again, could have put additional strain on it so that it occurred early in the launch phase.

Mr. NAGLE. The chairman had questions about the schedule and the impact on it.

Mr. NELSON. How long between the acceptance test and a launch?

Dr. FLETCHER. It's different for each engine, and possibly even different for each pump. In this case it was—what, a year?

Mr. ABBEY. No, it wasn't that long. We'd have to go back and give you a time on that.

VOICE. The shortest time is about 5 months.

Dr. FLETCHER. Do you know what it was on the one that cracked? Thirteen months in the case of the one that was cracked, Mr. Chairman.

Mr. NELSON. Is that significant in your evaluation?

Dr. FLETCHER. Yes, it is, but we really ought to be able to store engines for a year or more, and we need to have assurance that we can do that. But you're raising another point. Until we're sure we got rid of the problem, shouldn't we try to use fresh pumps? I think we'll have to look at that possibility. We don't always have that luxury

Mr. NELSON. So you're on a time schedule now for mid-March, and as far as you are concerned, you think you can get off at that time and clear the pad so that you can prepare Magellan?

Dr. FLETCHER. That's correct, Mr. Chairman. It's a tight schedule, I don't want to minimize it. And we have agonized, and we're going to still be agonizing all the way through this.

And by the way, I think it ought to be added, to make the first part of the Magellan window, we can make this change out and still have enough slack. It may be that we'll be forced to eat into some of that window if we run into problems, especially if we run into problems on the Atlantis, which is going to launch the Magellan. But we do have a 25-day or so window, so we can afford to eat into it a little bit. But we don't want to eat into it too much.

Mr. NELSON. Dr. Fletcher, there have been several internal reports that faults NASA's ability to control the cost on subcontracts managed out of NASA Centers. Do you intend to recover those amounts that you have discovered that have been overcharged by subcontractors?

Dr. FLETCHER. Mr. Chairman, we have implemented, if you like, but maybe reinstigated a more careful and more intense internal audit system that has been applied to subcontractors. Basically, the amount of internal audit we do in any company or in any facility like ourselves really depends on how much manpower you put on it. And we have found some cases of overcharging, and we have, the Center has responded very quickly to those and, in fact, I think are in the process of recovering the money. We will continue to do that. This is not a new thing. As we penetrate deeper and deeper into the organization, we'll be finding more of these, but so far our Centers have been very cooperative and the contractors so far have also gone along with our findings.

Mr. **Nelson**. And so you're saying that you're going to penetrate further and what? What are the steps that you're outlining so that NASA will continue to penetrate further?

Dr. **Fletcher**. Well, we do that in 2 ways, Mr. Chairman, and somebody from the procurement side of the house might want to speak to this. We do manage the contractors and then the subcontractors through the prime contractor, and the oversight of that contract, contract administration we call it, has been intensified to the extent that we can with our limited number of people. We are shorthanded on people, as you know. And then in addition to that we have the Inspector General, who has an internal audit function now, which has only recently been added to his responsibilities, and he also, not over the whole of NASA but to the extent that his resources will allow, is sampling various Centers. And the combination of those two has uncovered some substantial overruns, and I think they've been resolved so far.

Mr. **Nelson**. And is your statement that you are intending to recover from these overcharges?

Dr. **Fletcher**. I think that's correct. Mr. Foster——

Mr. **Fournier**. Mr. Chairman, Foster Fournier.

Our Centers are looking at that and will work with the prime contractors. Each of our Centers is taking the things that were raised by the Inspector General's audits and are working with the prime contractors to determine if there—in a case where there was overcharging to see, and if it's appropriate, they will go back and attempt to get the money back.

Mr. **Nelson**. What we want you to do is, where you have evidence that there was any intentional overcharging—go ahead.

Mr. **Fournier**. This is not really a case of overcharging. The issue was excessive profits, is what the Inspector General raised, and this is where they thought that the profits on fixed price contracts were too high. And in the case of a fixed price contract, fixed price subcontracts, you've got to—there are cases where some contractors made a high profit on one contract and a lower profit on another. But those are not necessarily a case of fraud or anything else. It's a case where the profit level on a fixed price contract was too high, and the subcontractors were taking a risk under those fixed price contracts. So we've got to look at those and see if there was—if there's a defective pricing issue where it's a violation of a certificate of current costs and pricing, we will in that case go back and pursue the defective pricing in any of those cases.

Mr. **Nelson**. Are you saying it is a matter of defective pricing which is part of the RFP process?

Mr. **Fournier**. In some cases there may have been defective pricing, and those we will certainly pursue. In other cases it may be just that a high profit was realized on a fixed price subcontract. When the prime contractor goes to the subcontractor and asks him to do work on a fixed price basis, there may be contingency in there in case of risk, and if he doesn't incur all those costs, then he will make a higher profit.

Some of those contracts, subcontracts in there showed a higher profit whereas others showed very low profits and losses. And that's the name of the game in fixed price contracts.

Dr. Fletcher. Mr. Chairman, I'd like to add something to make sure we understand each other. There are two separate functions of the IG that we've implemented. The first one is the investigative function, looking for fraud, waste and abuse, and that one has been ongoing ever since the IGs were formed. What we've done is recently, just this year, I believe, or maybe a year ago, is implemented what we call an internal audit function. This is the business of looking at how well we're managing programs. In this case, how well we're managing our subcontracts. And this is not a question of fraud or criminal activity, it's a question of how well we're doing at managing. That's what internal audit means to me, and that's a term used from industry. I don't know whether we call it that in government.

And they found some that looked like we could be better managed. And if it's right, we'll get our money—we'll get some money back, and that's I think what Mr. Fournier is trying to say.

Mr. Nelson. Well, I read a newspaper account, and the genesis of my question is that when I read this newspaper account it was suggesting that there were these significant overcharges that were being made by subcontractors to the contractors. Now when I read that I didn't like that one bit.

Dr. Fletcher. Mr. Chairman, I read that, too, and I immediately called the Inspector General and asked what was going on, and he said, "Hey, they got the investigative function mixed up with the internal audit function." And these were not fraud, waste and abuse, but this is simply a management question and the IG was raising the issue, and I think that's the correct answer.

Mr. Nelson. Well, is the bottom line is a subcontractor getting more than he's entitled to legally?

Mr. Fournier. There are different situations. In some cases he is not getting more than he's entitled to legally. He bought in to do work for the prime contractor for a fixed price, and he completed the work and was paid that fixed price. In some cases he got more profit than we would have anticipated when we went in. And maybe the prime contractor didn't do as good a job as he could in negotiating the original price, and maybe we in the government in some cases didn't do as good a job as we could in negotiating the prime contract to ensure that the pricing of those subcontracts was done properly and to ensure that we didn't allow too much contingency in there. But there's a judgment in those things and you can't always estimate correctly what the ultimate cost is going to be. But it's the final cost that determines how much profit you made.

And the IG was able to go into the subcontractors and ask them what their actual profit was on completed subcontracts. Some of them lost money; others made what seemed to be very high profits, 80 and 90 percent; some of them made 10 percent; some of them made minus 5 percent—but there are a range of those things.

Mr. Nelson. Where there was the high profit, I don't mind high profit as long as it is legal. Was it legal?

Mr. Fournier. In most of the cases——

Mr. Nelson. Can you answer that simply, instead of a lengthy answer?

Dr. **Fletcher**. I think a short answer is in most of the—all of the cases that we've looked in the last year there is no evidence of illegality. I think the IG would support me in that.

Mr. **Fournier**. I think that in most of the cases that's right. I think there may be some where the IG raised the question of defective pricing, where at the time—under truth in negotiations, at the time of negotiation you should give the government or the prime contractor complete, current and accurate data. There may be a couple of instances in there where that was not done, where we didn't get complete, current, and accurate cost data. That's defective pricing, that's wrong, and we go pursue that to get the money back.

Mr. **Nelson**. Then if that's——

Mr. **Fournier**. There's been a few of those in there, but most of the IG's report did not get into issues where they thought there was defective pricing.

Mr. **Nelson**. All right. If you're saying that you have no evidence of illegality, and yet you say that you have uncovered some excessive profits being paid, then somebody is not doing their job.

Dr. **Fletcher**. That's—now you're hitting it, Mr. Chairman. That's the whole point. This is a management question and a judgment question, and how well you manage contracts is a negotiation business. This fellow makes excessive profits, then we misjudged how easy or hard the task might be. And that's what the internal audit function is supposed to catch, how well we manage our contracts.

Mr. **Nelson**. Dr. Fletcher, is there any evidence that that mismanagement is in NASA or in the contractor or in both?

Dr. **Fletcher**. Probably it's a combination. Because we tend to manage the contractors much more, except recently, than we do the subcontractors. In fact, we can't really manage the subcontractors. We can audit them and that reflects, then, on the prime contractor. And I can't really break down how much was—mismanagement I don't like. I'd say careless management rather than mismanagement. How much was prime contractor and how much was NASA.

Mr. **Nelson**. Well, let me just tell you I really want you to get on this one because we scrapped, as you know, for every dollar that we could get last year and we just simply don't want to see any of it frittered away in some way that is not going into the good of the program.

Now let me ask you about ACTS, Dr. Fletcher. Here we have this Advanced Communication Technology Satellite. We've gone through and we've spent what, close to three-quarters of a billion dollars? Three hundred million? We've spent 300 million over the course of many years, and your budget comes to us and it zeroes it out. Can you explain?

Dr. **Fletcher**. Yes, Mr. Chairman. This process started long before I came back to NASA, but at the beginning of the Reagan Administration it was felt that the government should only support—I've forgotten the words—high-risk, long-term industrial activity, and this was felt early on to be not high risk and therefore should be left to the private sector to do. In fact, in other countries the private sector is doing a lot of this—Japan, for example. We, nevertheless, did start the program. I gather because Congress went ahead and appropriated the money.

And so it's a good program and it's on track, but we go through this exercise every year where it's more properly a function of the communications satellite industry in the minds of OMB, and in the minds of the Congress it is an appropriate thing for the Federal Government to do, and I'm afraid we're still in that, I don't want to call it a dance, but this exercise.

Mr. NELSON. Is there any evidence that, under the present scenario that we will beat Japan to the marketplace with ACTS?

Dr. FLETCHER. The answer to that is a complex one, and I will start but others here are more expert. In some respects they are, they will beat us to the punch. Particularly in the case of the 20 and 30 gigahertz frequency, which was one of the initial purposes, it may very well be that Japan will get there first.

On the other hand, there are other aspects of it which has to do with the way the system works on the satellite, how you switch the beam and how quickly you switch the beam, and other aspects of it, that I think will be a major leap forward in the case of ACTS, and it is clear at this point at least that the Japanese will be ahead of us at the time the ACTS is completed.

Now I ought to turn to the experts. Dr. Fisk, will elaborate on that.

Dr. FISK. Well, I really won't say much more than you've said. You are correct that the main leap forward comes in the beam hopping and on board processing associated with ACTS. There are aspects of those which are included in both Japanese and European satellites, but not in their entirety, and if we launch in May of '92 we should still be ahead.

Mr. NELSON. How about the ground facility? Who's going to gain there?

Dr. FISK. The ground facility, at the moment, the intention is to use the ground facilities in 2 ways: to seek from the industry funds to do that aspect. You'll recall that this program is capped at $499 million and that in that cap there is no funds for ground facilities associated with ACTS. As was mentioned, we proposed this year but we're not funded for the use of some ground facilities to use as—by the Government for shipping science data around. It actually occurred to us that a good way to test the facility, the ACTS on orbit, and to demonstrate the technology was to use it in the context of our own programs, and to do that with ground facilities that the Government bought and perform that function. But since ACTS was not included in the budget, neither was those ground facilities.

Mr. NELSON. What about getting to the marketplace first on the ground facilities?

Dr. FISK. Well, at the moment we are, assuming that ACTS is still with us is the assumption, we are working with the industry to provide the financing for the ground facilities as was the intention, and that we will certainly use ACTS beginning in May of '92 when it is launched and that will—since we are ahead of, slightly ahead of our Japanese and European competitors our ground facilities will be there first.

Mr. NELSON. And do you have an opinion about whether or not—by us getting there first, whether or not we can capture a sizable part of that market?

Dr. FISK. Well, I think as in all cases of a technology satellite like this we are demonstrating a technology which is in many years—many years ahead even of when we are using it. It is a proper role of the Government to demonstrate technology which the industry is unable to invest in, and to the extent that ACTS performs that function we're demonstrating technology which will be incorporated into satellites which are not to be launched within the next few years immediately following ACTS but within a 5- to 10-year period thereafter.

One of the reasons that the actual race to who is there first is it's only a—it's not a question of being there first in a precise way, but to be there in the same time frame so our industry has access to that technology when they begin to build a generation of satellites that occurs sometime thereafter.

Mr. NELSON. Let me follow up on this and I will get back to you, Mr. Nagle.

There is some good news. In addition to a number of the good things that we've been talking about here and what I was able to compile last week after asking our staff, I wanted a follow-up on our commercial ELV bill that was signed into law I think the middle of November, and lo and behold, what we found is that there are now 26 payloads contracted with money paid on American ELVs, and that is a rather strong testimony by virtue of the fact it's what a lot of us in this room had been working for, to get some risk sharing, some adequate and appropriate pricing of government facilities, risk sharing with the government on liability and property, and that the proof is in the pudding. Now, instead of those 26 payloads going on foreign carriers, the fact is they're going on American ELVs. So I am just delighted in that. I mean, if we've seen something work, it's starting to work. Do you have any comment about that, Dr. Fletcher?

Dr. FLETCHER. Well, I think you've said it all. The contractors are all involved in a wide variety of ELVs and there's new contractors coming on board all the time, especially for the smaller payloads. They've signed up. Now they've got to produce, and I'm optimistic that they will not only produce better than our foreign competitors, but I hope in the long term less expensive, although the jury is out on that.

Mr. NELSON. Well, I think we've got some very optimistic future there with regard to the use of government facilities now to get this new, fledgling industry off the ground, and it looks like it's going to get a good chance now to see if it can make it.

Now, with regard to ELVs in the government area, let me just remind you of the urging of this committee for you to acquire ELVs to use at every juncture that you can afford them so that you can free up that space and let the cargo of the Space Shuttle be used more uniquely for what it is capable of doing. Are we in sync on our philosophy here?

Dr. FLETCHER. I think so. The key words that you used were "to the extent that our resources will allow," and we're going down that path. We have ELVs programmed in the future launches and we're going to continue on that route.

Mr. NELSON. When did you finally give up the ghost and agree to an ELV for Mars Observer?

Dr. FLETCHER. I don't remember. My own feeling was that we always did feel that was a good idea. Mr. Chairman, we've been in a lot of arguments on this, but I think the biggest argument was whether we could get an ELV in time for a 1990 launch. When we found that we couldn't we postponed the launch till 1992, then ELVs became easy, and that's what settled the question.

So I think that the delay in the launch is what solved the problem.

Mr. NELSON. Well, it wasn't that readily apparent to us.

Dr. FLETCHER. I know. But I hope that one is behind us. We're in good shape there.

Mr. NELSON. I think it's behind us now, but you guys sure did kick and scream and drag your feet on that one. That one's one that I almost let Mr. Nagle out of his cage on. [Laughter.]

Mr. NAGLE. I'm ready. I'm ready.

Mr. NELSON. Go ahead.

Mr. NAGLE. Well, as long as we're on that——

[Laughter.]

In light of what we talked about today, I think we've talked about it before, the problems of the, I think it's the STS 27 cracks, the directions to the agency to use man in space when man is needed in space and not unnecessarily, in light of the impact of the most recent pronouncement of the delay in the launch capability to March—I know that's your best guess today—how are you coming on the Shuttle C?

Dr. FLETCHER. I'm going to ask Mr. Myers to elaborate, but the Shuttle C is in the study phase right now and I think we—it's planned to use previous year funding for that. There is no funding in fiscal '90 for the Shuttle C.

Mr. NAGLE. Why not?

Dr. FLETCHER. And the reason is the Shuttle C has now become a part of the Advanced Launch System Program and it's being considered as a possibility for the future Heavy Lift Launch Vehicle. I don't think that's the end of the story. I think the Shuttle C will come up again during this year's discussion. I think it's a fine—splendid program. If we can get somebody to pay for it, we'd like to go ahead with it.

Mr. NAGLE. Where's the resistance coming from?

Dr. FLETCHER. The dollar, primarily. We don't have enough money to go ahead with it—we, the Nation—and do all the other things we want to. There are some other problems, and that is, we have to—whatever launch vehicle we decide on, we have to get the Defense Department to sign up for it, because we do have a joint program on transportation. I think——

Mr. NAGLE. Would you say—how would you characterize the Defense Department's attitude towards the Shuttle C?

Dr. FLETCHER. I think Mr. Myers has been involved in some of those debates, more than I have.

Mr. MYERS. Yes. I think we're all looking at—both sides are looking at a clear need to move forward with a new launch vehicle.

Size and configuration and what should be this new system has been the subject of study now for several years, and I think we're beginning to converge. There is continuing study using 1989 money on the shuttle that will carry—Shuttle C that will carry it through a definition phase this year, and at the same time there are studies going on, as you know, a joint program with the DOD with NASA on the Advanced Launch System. We are responsible for the new liquid rocket engines and are responsible for the leadership in the technology program.

All that is extremely good work that has led into better technology programs in NASA and I think a convergence of views as to where this program should be going.

Mr. NAGLE. Is it a fair statement, Mr. Myers, that if we got going on the Shuttle C we could have it—we got it—if we've made a commitment to the Shuttle C now, we could have it operational by, at the latest, '95?

Mr. MYERS. Yes, I think that's right.

Mr. NAGLE. And possibly '94?

Mr. MYERS. Yes. The Shuttle C has so many good things going for it in terms of reliability and use of existing parts and so on that there is not a major development activity associated with it, so times of development are relatively short.

Mr. NAGLE. And is it not true, if I've been informed correctly, that the Shuttle C is very, very cost effective if used on an average of not greater than 5 times per year?

Mr. MYERS. Well, we've looked at it as fitting—you know, you got to worry about the upper stages that go with it, too. And in the overall picture, we see it as a very logical system at about 2 or 3 a year.

Mr. NAGLE. Um-hum. Um-hum. And I think but up—you can go out, some studies would indicate?

Mr. MYERS. Oh, I think you could lead, you could lead on up to——

Mr. NAGLE. To 5.

Mr. MYERS [continuing]. Say, 5 a year.

Mr. NAGLE. Yes.

Mr. MYERS. We've planned—we've looked at it as using shuttle facilities. We also look at it as an opportunity to use the shuttle facilities on the West Coast.

Mr. NAGLE. Now, isn't it true also that if we go to the Department of Defense's ALS system, this Advanced Launch System, that that could not be on line and usable until about the year 2000?

Mr. MYERS. Well, a part of that is money and part of it is requirements. Studies that they've made talk about 1998, and the studies they have made have really led to quite large launch rates, so all of that has to be balanced out as to when they would have it, but it's the '98 time period for the brand-new system.

Mr. NAGLE. Now how many launches will it take of the shuttle—first question, when do we want to put, when do we want the Space Station in orbit on line?

Mr. MYERS. The first element is launched in 1995.

Mr. NAGLE. And it's to be operational by when?

Mr. MYERS. Well, permanently manned by '96, and then with all the elements of the European and Japanese activities.

Mr. **Nagle**. Now how many launches, just to review the record, does it take of the Space Shuttle, with the risks inherent in the Space Shuttle, to put the Space Station into place?

Mr. **Myers**. I think it's——

Dr. **Fletcher**. Nineteen.

Mr. **Myers**. Nineteen, yes.

Mr. **Nagle**. Yes. Um.

And how many launches would it take with—used in conjunction with the Shuttle C to put it into place?

Mr. **Abbey**. Right now we've identified at least 4 of those flights. To date, we've identified at least 4 of those flights that could go, and practically from an assembly standpoint and from a schedule standpoint that could go on a Shuttle C. Those come in the late '96 or early '97 time frame.

Mr. **Nagle**. Now if—how much would that reduce the number of flights needed from the orbiter, or from the shuttle?

Mr. **Abbey**. Well, at least, assuming we didn't find any others, it would be at least 4.

Mr. **Nagle**. Well. If I understand the preliminary discussions on the Shuttle C—if I understand the preliminary discussions on the Shuttle C, it's capable of lifting up to—what, 150,000 pounds of payload?

Dr. **Fletcher**. Yes.

Mr. **Myers**. Oh, yes. Hundred and fifty thousand with 3 engines.

Mr. **Nagle**. Three times the amount that we're currently allowed to lift on the——

Mr. **Myers**. Of that order, roughly.

Mr. **Nagle**. Because we're restricted to 50,000 on the shuttle, right?

Mr. **Myers**. Fifty-two, I think. Of that order, yes.

Mr. **Nagle**. Yes. Isn't it a factor, then, that by having the Shuttle C we could get that station up much quicker?

Mr. **Myers**. Yes. From a pure mass standpoint, your point is exactly right. The thing that is the limiting constraint is the hardware that we put up in many cases, in most cases, except those 4, has to have the crew there in the immediate vicinity to then start the assembly and get the spacecraft assembly completed and back under control, I'm told, as a spacecraft.

So, even if we took the Shuttle C up in many cases, I would still have to have an orbiter there with the crew to effect the assembly.

Mr. **Nagle**. But we would be able to get at least 4 launches and substantially more weight into orbit for the Space Station with a Shuttle C than we would with the shuttle itself, or the orbiter, is that correct?

Mr. **Myers**. That's correct.

Mr. **Nagle**. All right. Well, I guess what I'm concerned with is, is that, you know, as we refine the process of the shuttle launches and as we become more safe as we experience—we only have experience in 27 launches right now, I think 27, but we still every time we launch that shuttle we certainly run a risk. I think we'd all agree to that. But a Shuttle C disaster, while it's certainly a disaster, is not of the magnitude that a shuttle orbiter disaster would be, obviously. Yes.

What—I guess what I'm, what I'm questioning on is, if the ALS would not be launchable until '98 after the station is supposed to be in place, can we look for any progress or a breakthrough on that this year in light of the fact that you haven't requested any money for it? I mean, not you, but the Administration hasn't requested any money for it.

I think there are a number of us on the committee would like to see that Shuttle C accelerated, or at least kept on-line.

Let me add one other thing. If the Shuttle C comes on in a '94 or '95 time frame, and depending on its capability and how we end up in the final design of the Space Station and the assembly, there may be more than the 4 that I've identified. That could be. I'm just saying, with what I know of the Shuttle C right now and it coming on line in the '96 time frame, I can only identify 4.

Dr. Fletcher. Yes. Mr. Nagle, I'd like to elaborate on that. We haven't asked the Space Station folks to assume a Shuttle C, what could you do if you had a Shuttle C. That's not part of their assignment. I'm sure there are innovative ways of using the Shuttle C that just haven't been thought of yet, in not only assembling the Space Station, but in resupplying it. A lot of the change-out experiments and so forth could be supplied, and we may want in phase 2 of the Space Station to put some of those pieces up. And so there's a lot of things you could do if you had a Shuttle C, and it would be a very useful thing to have in 1995. No question about it.

Mr. Nagle. What's the prognosis for it, then?

Dr. Fletcher. Well, it's a matter of money and getting the Nation to sign up to the fact that we want to spend what is estimated now to be about $2 billion for the development. It's not really development, but putting together of a Shuttle C and testing it. I think mainly it's a money problem.

Mr. Nagle. It is kind of hard to get the Nation to ask to sign up for it when we're not requested to do it.

Dr. Fletcher. Quite right. And we have—we do our best to put a budget together, and when we put it together we sometimes drop out things that we'd really like to have, and the Shuttle C is one of them.

Mr. Nagle. How long do you think, if you could prognosticate for me, it will take the Department of Defense and the NASA people and the Administration to resolve this interagency conflict?

Mr. Myers. I think there's evidence that probably this year there will be a resolution in this area.

Mr. Nagle. And if there——

Mr. Myers. Let me tell you why. There is a—the ALS is in a study phase that would lead to definition of a configuration in about a year. I think that definition of the configuration is very honestly being looked at between DOD and NASA as to does the Shuttle C fit into that whole picture. It may be that an ALS should be a smaller vehicle that is very rapidly responsive in military uses of the shuttle—excuse me. The ALS may be a smaller vehicle and then complemented by a larger vehicle, the Shuttle C.

Mr. Nagle. That would be the cart before the horse in any study I've seen, Mr. Myers.

Mr. Myers. There are studies that would lead in that direction. And I think there is——

Mr. **Nagle**. Are you saying we could have an ALS on line by '94 or '95?

Mr. **Myers**. No.

Mr. **Nagle**. So we're going to be without a heavy-light launch vehicle unless we can get the dispute between the Department of Defense——

Mr. **Myers**. I'm saying the heavy-lift launch vehicle might be the Shuttle C and a more rapidly responsive smaller vehicle could be the ALS.

Mr. **Nagle**. Want a Titan V?

Mr. **Myers**. It might be something of that nature that might make a lot of sense. I don't think that I would envision—well, I don't know what will finally come out of this thing, but it seems to me that there's—reasonably that this Nation needs a new engine and a new airframe in the middle-size range. That's a Dale Myers' view of where the launch vehicle system comes in.

Mr. **Nagle**. The problem we've got, though, is that, if we continue the present course, we will make absolutely no progress in terms of a Shuttle C in 1990 because there are from the Administration—this is not your fault—no request for funds.

Mr. **Myers**. There is no request for funds in 1990.

Mr. **Nagle**. So we'll make no progress on it. So the best we could anticipate—would that, then, delay the Shuttle C's development out to the '95–96 timeframe?

Mr. **Myers**. It would delay it a year. We do not start it in 1990.

Mr. **Nagle**. How do I ask this question without putting the 3 of you on the spot? But is that, is that—is the decision of the Administration not to request any monies for the Shuttle C for the 1990 budget, does that meet with the enthusiastic support of NASA?

Dr. **Fletcher**. I think I'd have to answer that. We really would like to have a Shuttle C. I think the Nation needs something like a heavy-lift launch vehicle, and it's a shame that it wasn't started a long time ago. Unfortunately, we had other programs that came in that had higher priority, especially in the transportation arena. The ASRM, for example, is a case in point. We had to debate back and forth whether we needed an advanced solid rocket or a Shuttle C. Well, we opted in favor of the shuttle—the ASRM, and that's on track.

Mr. **Nagle**. Are you saying——

Dr. **Fletcher**. So it's a question of the total dollars, and I think the most we could get from the Reagan Administration was a 21 percent increase.

Mr. **Nagle**. Dr. Fletcher, are you saying—I appreciate the candor of your answer. I'd like to go back to you'd like the Shuttle C because I would, too. But are you saying that the choice then for the committee is in part between the ASRM and the Shuttle C?

Dr. **Fletcher**. No. Well, that is a choice of the committee. But that's the choice that we had to debate back and forth within our own organization, whether we were willing to give up the advanced solid rocket motor in order to get the Shuttle C funded, and the answer came out—George Abbey?—ASRM was needed more badly than the Shuttle C.

Is that a fair answer?

Mr. **Nagle**. Tell me why. I'm sure George can tell me why.

Dr. FLETCHER. Well, I can give you the arguments in favor of it. The shuttle is going to be operational for a long time to come, at least 20 years, and the solid rocket motor had a defect in it, which we hopefully have fixed, but it's still having problems. It's kind of a marginal vehicle, and we really need to have a way of building solid rocket motors that's much better than what we do now. And the advanced solid rocket motor gives us an opportunity to make a better, more reliable, safer solid rocket motor.

In addition to that it has the feature of additional payload, which we would like. It's not a trivial matter. It's on the order of 15,000 pounds or so.

Mr. NAGLE. Dr. Fletcher, let's be candid. First of all, the best estimate I've seen on the additional payload is 12,000 pounds. Secondly, there are many in the industry that feel the maximum you could go is 6,000 pounds. And thirdly, there's been no identified mission by NASA to take advantage of the additional payload.

All three statements are fair, are they not?

Dr. FLETCHER. Not quite, Mr. Nagle.

Mr. NAGLE. Close?

Dr. FLETCHER. It's close.

Mr. NAGLE. Thank you.

Dr. FLETCHER. The 12, I would agree with you on the estimate of 12,000 pounds. I think it's always possible that we've grossly misestimated the extra payload capability, but I think the 12,000 is probably close to the truth. The 5,000 is probably a lot farther from the truth.

The fact that—the other question, the last question you asked is a judgment question, and I don't——

Mr. NAGLE. Have there been any studies identified that you could share with me that specify a mission for the additional weight characteristics that the ASRM would give us?

Dr. FLETCHER. No, but I think that's not the right way to ask the question. The question is how much margin would you really need to assemble the Space Station, and we have what we think is an adequate margin. But we'll be continually working that problem over the years. Every time there is an increase in weight we're going to have to cut it back somewhere else. If you have an adequate, a larger weight margin for putting the Space Station together, you will—it'll reduce the cost. You'll be able to make decisions based on what's the right way to go rather than what increases the weight or not. So that's one area where the 12,000 pounds additional would make a difference.

Mr. NAGLE. Do I understand the ASRM would come on line in 1996?

Dr. FLETCHER. I think it's earlier than that. Nineteen ninety-four.

Mr. NAGLE. Okay. Go ahead, please. I didn't mean to interrupt.

Dr. FLETCHER. So the Space Station is one example of where the extra 12,000 pounds would give weight. I don't think you should—how to say this in a polite way. You build the extra lift capacity and then you figure out what the payloads are. You don't do it the other way around, unfortunately. We don't design a transportation system to fit a payload on the average. We design a payload and—I mean, we design a transportation system and then suddenly all the payload, new payloads appear. That's what happened with the shuttle. Everybody sized their payloads according to the shuttle, and that's where the Ariane got their message for building the Ariane for. It's compatible with the shuttle payload.

Mr. NAGLE. Question, the last one. If a member of the committee, or if the committee were interested in promoting the Shuttle C, if we anticipate between the lines correctly that in the heart of hearts of NASA that they'd really like to see a Shuttle C, what recommendations, if any, would you make to this committee that we could take to see that the Shuttle C, in fact, comes on line; that the interagency discussions going on between the DOD and NASA and the Administration are resolved?

Dr. FLETCHER. That's a good question——

Mr. NAGLE. How could we be helpful?

Dr. FLETCHER [continuing]. Again, Mr. Nagle, and I'm trying to think the best way to answer it. It's hard to answer in public. But there are discussions going on between us and the Air Force, and I think—I'd hate to suggest the way you should get involved in those discussions.

Mr. NAGLE. Well, I think that, you know, we look to NASA for the lead, and it's somewhat difficult in the last 2 years because I think NASA's lead has not always been adhered to by the Administration because of policy considerations the Administration has made, wisely or unwisely. I think we'd like to be helpful and I think there's a consensus within NASA that Shuttle C would be a nice thing to do, an important thing to do, and a proper thing to do, and remove the risk to life. But it's hard for at least one member of this committee—I don't know how the chairman feels, but it's hard for one member of this committee to be helpful and advocate for you when I can't get any ammunition to do the advocating. I mean, it's hard to shoot the gun if you don't have the bullets.

Dr. FLETCHER. Well, let me summarize my position, Mr. Nagle. I'm an outgoing Administrator and I can probably speak a little freely. I think the Shuttle C is a beautiful idea, and the Nation needs it. And I think for $2 billion spread out over a 4- or 5-year period is a nit in terms of the overall deficit problem.

I think that it was clear that the previous Administration did not want the Shuttle C. I think it's a new ball game with the current Administration, and I think somebody ought to raise it again. I know I'll probably get my wrists slapped, but it doesn't matter that much for me.

Mr. NELSON. Mr. Nagle, you just got a new bone thrown into your cage. [Laughter.]

Mr. NAGLE. I thought I was a nice guy.

Mr. NELSON. Start boning up.

Mr. NAGLE. I thought I was a nice guy. List me on a resume for recommendations, if he's looking for a job. Hell! I'm just trying to get along here. [Laughter.]

Mr. NAGLE. Got to feed the bear.

Mr. NELSON. For those who are going to be intimately involved as you transfer into the new Administration, let me offer a couple of suggestions on behalf of the committee. A couple of them we have already talked about today.

The Space Policy Council—this committee would like to see that instituted immediately, and activated immediately. And, although the law that we passed did not call for a vice chairman to be the Administrator of NASA, that's what we think ought to be. The law calls for the chairman of the National Space Policy Council to be the Vice President of the United States. Harkening back to the times when we had our original Space Policy Council, it was the Administrator of NASA that was the vice chairman, and that would be the preference of this committee. So I wish you all would help us get that message along.

The second thing is that under the existing law that we ought to try to unfence the $515 million on the Space Station and get every economy of scale and economic efficiency out of there. Everybody knows we're going to spend the entire $900 million in this fiscal year. Now let's do it wisely. The fence was put in there for a political reason to begin with, and that was to give the new President a choice whether or not he was going to proceed with the Space Station. And since this President has already determined that, then what we need to do is remove the economic fence so that we can get the economies of scale.

Another recommendation would be that it is a pittance in an almost $2.4 billion increase in NASA that you're only getting in this budget request a $42 million increase in research and technology efforts. That's a part of our seed corn. We need it increased.

And likewise in R&D, the Pathfinder has only grown $7 million, from $40 million to $47 million. We have had informal conversation that Pathfinder should be funded at the level between $100 and $200 million a year. Now that's a big order for us to take on.

Another suggestion—in the realm of commercial programs, out of a $13 billion NASA budget, only $61 million is requested for commercial programs. And commercial programs through NASA can be the leverage to really open up into the private sector, so this committee seriously questions whether that is adequate resources. And, of course, we're going to hammer away at this stuff this year as we dig into this budget, but for the sake of those people who are transitioning to the new Administration, I want those 5 points noted.

Mr. Nagle, do you have anything else?

Mr. NAGLE. Mention the Shuttle C, too.

Mr. NELSON. And the Shuttle C. Absolutely. There you go. That's a sixth point. Straight from Dr. Fletcher, since he can't get into any more trouble.

Dr. FLETCHER. Hopefully.

Mr. NELSON. All right. I would like to just recognize Captain John McBride, who has been our very able congressional liaison, who has now been named as commander of a mission—March, a year, on the Astro mission, which he was going to command 3 years ago. So it's better late than never, Jon. But we have certainly enjoyed working with you, and know that you'll be returning to Houston now to start preparing for your mission, and we're happy for you. Real happy for you.

Does the staff have any further comments or questions?

[No response.]

Mr. **Nelson**. All right. Thank you, and have a good day.

[Whereupon, at 4:48 p.m., the subcommittee was adjourned, to reconvene subject to the call of the chair.]

1990 NASA AUTHORIZATION

TUESDAY, FEBRUARY 28, 1989

U.S. House of Representatives,
Committee on Science, Space and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met at 2:30 p.m., in room 2325, Rayburn House Office Building, Hon. Bill Nelson, chairman of the subcommittee, presiding.

Present: Representatives Nelson, Volkmer, Sensenbrenner, Rohrabacher, Torricelli, Lewis, McMillen, Smith of Texas, Schiff, Mineta, Perkins, Stallings, Smith of New Hampshire and Walker.

Also present: Representative Andrews.

Mr. Nelson. Good afternoon. We are looking forward to having this hearing on the subject of the space station to get up to date on NASA's plans for the space station and to answer some of the questions that our committee have raised about it.

Then we are going to have Dr. Peter Banks, who has recently written an article in Scientific American about the Soviet space station. We are going to have him available for some questions of the committee so we might have some of our interest in that program answered.

It is good to have you here, Mr. Odom. We have been round and round on this, and you all look like you're about to step out and proceed. There are things that are slipping on your schedule that we do not like, there are slots that are unfilled that we are concerned about, with the bottom-line result that it may mean that we are seeing slips in the schedule. And we want you to assure us that that is not the case.

In the process then you can then tell us so that we can go out and continue to sell to the Congress the appropriate amount of money that is needed for this project which is so enormously important to our country.

So, if you will share with us, I would appreciate it.

I am sure they have told you I do not want you to read the statement, I just want you sharing with us, and then we will get into the questions.

STATEMENT OF JAMES B. ODOM, ASSOCIATE ADMINISTRATOR FOR SPACE STATION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY RAY TANNER, DIRECTOR, SPACE STATION FREEDOM PROGRAM OFFICE; AND PAUL G. ANDERSON, DIRECTOR, RESOURCES AND ADMINISTRATION DIVISION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. ODOM. What I would like to do initially, Mr. Chairman, is introduce Ray Tanner, on your right. Ray is the program director at the Reston organization; and Paul Anderson, head of program control, who helped put this budget together.

So, the three of us are delighted to participate this afternoon and describe the program to you and answer any questions that you might have.

I would also like to submit my formal statement for the record, which you have.

Mr. NELSON. It will be included as part of the record.

Mr. ODOM. Thank you, sir.

I think my statement describes fairly clearly and fairly concisely where the program is, where it's going, what the progress has been, and what the budget requirements are.

I would also like to give you my own summary of where the program is. What I would like to do, as I said, is indicate to you in some fashion what my testimony says. But more important, it is important that we really understand what the Space Station Freedom is about. It is about the human exploration, and equally and probably certainly as important, the exploitation of space.

So often we tend to look at one particular aspect of what space stations will do. I would like to, in the course of my discussion and summary this afternoon, get into that in much more detail.

I think for science the Space Station Freedom certainly offers a manned laboratory in space. The Freedom also offers a platform that is not only looking out at the universe but equally important, and probably in the next few years more important, looking back at the Earth and helping us to understand the Earth and the environment in which we live.

I think the Space Station Freedom program complemented by the polar platforms and the manned base, I think, will do an excellent job in helping with that.

It is not only a unique facility, but it is a test bed for evaluating techniques, technologies of the future before those are put into actual application either in space systems or in terrestrial systems.

Automation and robotics is also one of the things. The control of large flexible structures is another part of this program. And we will learn early on, as soon as the station is put together and is operating, how to control man's environment. The control of power, the distribution of power are just a few of the things that will be done in a much larger and greater degree than we have ever done them before.

That too will be a learning experience and one that will lead us into many avenues in the future for exploration. The manned base represents, I think, the establishment of a permanent outpost in space. That too will be extremely important. It will be a place to prepare mankind's next step outwards to the planets or back to the moon. Whether our next destination is Mars or the moon, the space station is really the next step with which to get there.

The space station also offers opportunities to the private sector. The resourcefulness and innovation that have served our Nation so well in the past I think should be applied to this program. And let me assure you it will be. The laboratory, the workshop, the observation platform, construction facilities, production facilities, service station, and way station, all of these I think describe the roles that the Space Station Freedom will provide.

It also offers an extensive set of capabilities to support a very wide range and support of a broad spectrum of users. And you will hear more about that.

For this reason, the Freedom is the core of our space activities for decades to come. The benefits the Nation will receive from the space station are not just limited to the space program.

One sector here on Earth that would benefit greatly would be our educational system. The Space Station Freedom, I believe, will offer an avenue and a focus of interest for our young people for many years to come that will stimulate young people to enter into the fields of math, science, and engineering, and I think Freedom will be a freedom for that interest of these young people.

I think it is very important that we recognize that the Space Station Freedom really will be operated by the people that are still in school today and have not yet voted. So, I think to really talk Freedom is to talk the future.

The capability to conduct rapid-response experiments for undergraduate and even graduate students within the two-year graduate period I think will be an asset that the space station will provide that will also stimulate not only our education at higher levels, but also stimulate additional research. These influences will strengthen our national competitiveness and also enhance our well-being.

In light of the objectives and magnitude of this endeavor, it is appropriate that the United States is including its friends and allies. As you are aware, we have involved Canada, Japan, and nine members of the European Space Agency to make this station an unparalleled effort in international science and technology cooperation.

I would like to move now into some of the accomplishments that we have had recently, and let me assure you there have been plenty. We have assembled an organization to manage the complexity of a program of this type. It is the strong program office at Reston that is headed up by Mr. Tanner. It is dedicated not only to the program control and resource management, but the systems engineering and systems integration that is necessary to make this program happen.

Five major center are also managing the key elements of the program that are distributed around the country. Our industry team is on contract. It is in place, and it is ready to go.

We have secured firm commitments from our international partners. Last summer we signed the international agreement by the Secretary of State with the officials of 11 other Nations. We have also signed memoranda of understanding with our partners that sets the programmatic and the rules by which I will interface with my counterparts in these countries. These agreements will be the foundation for three decades of space endeavors.

With these important milestones behind us, we are now immersed in the design and development of work that is at the heart of this program. Design of the Space Station Freedom and its elements are progressing quite satisfactorily.

Our advanced development program is showing excellent tangible results. Here are a few of examples of just the kinds of hardware that we are literally building and testing as we speak:

We have built prototypes of the rotary joints. We have also built the prototypes of the control moment gyros that is needed for pointing and stability of the space station. We have also built prototype solar rays for the power generation. Substantial work has been done also in the environmental control and life support system—a very critical subsystem for the space station.

Development work on advanced robotics has also progressed significantly from the course of this year. In total, we are working and testing on literally hundreds of pieces of hardware as we speak, including prototype test beds, breadboards and brassboards.

These represent the much higher risk items. That is why they are up front. That is why we are already testing them and developing those pieces of subsystems, systems, and black boxes which will, in turn, reduce the risk in the early part and the latter part of the program.

However, the greatest challenge of this program is not technological. Instead, it is the management and engineering challenge of building a remote facility that can be economically operated and productively operated for a 30-year period. And believe me, Mr. Chairman, that is truly a challenge.

Consequently, we must take a long-term view of the space station's design. Life-cycle cost has been and will continue to be a very major element of this program. We are minimizing future operating costs by designing Freedom so that it can be operated cost effectively. We are about to implement a program control system or mechanism that will allow us to manage the life-cycle costs.

We are also making a very strong effort to ensure that users' needs are adequately met. Similarly, we are designing Space Station Freedom's systems in the elements to easily accommodate the technologies of the future which will happen over the course of the next 30 years.

I am pleased to say that the Space Station Freedom is still on schedule. Our first element launch will take place in the first quarter of 1995, permanently manned capability in the fourth quarter of 1996. Assembly will be complete in the first quarter of 1998.

Those are the same major milestones that we presented to you last year. We intend to stick to this schedule.

And this now brings me to the FY '90 budget request for the Space Station Freedom. The requested $2.050 billion is mandatory to continue to meet our cost and schedule commitments. This amount is consistent with our projections of previous years. This increase is necessary if we are to design and build the right space station as I have described.

Almost two-thirds of this funding will be going directly to our prime contractors. The remaining third will be going to the supporting contractors.

So, in the hardware the dollars are for a fact going into the design and development to the maximum degree we can cause it to happen.

Ground facilities and testing facilities are also progressing quite well and receiving funding this year.

NASA is again requesting a three-year advanced authorization and appropriation of $8.5 billion for FY '90 through 1992.

A program development cost ceiling in 1984 dollars is also in our legislative proposal. By increasing programmatic stability and continuity, the overall cost effectiveness of this program will be enjoyed.

There are three other budget issues that I feel must be addressed. The first is manpower.

As the efforts of our contractors expand, so does the NASA's oversight need to expand. We will be going from approximately 15,000 contractor workforce this year to about 32,000 by the end of next year. In that, consequently, we will need additional manpower to manage that resource.

Another important issue is facilities. For our centers to continue the excellent work that they have been doing in the programs in the past and continuing in support of this program, we must maintain those facilities, and build the new ones as they are determined to be mandatory. This is not something I think we can continue to skimp on.

The remaining issue is the commercial involvement. We are vigorously pursuing commercial participation in the Space Station Freedom program. This budget request assumes private sector does several items, which I have described in detail in the rationale along with the detail of my statement to you.

The private sector, I believe, has much to offer. I believe it is incumbent upon us to work that system and to understand it and make it as productive for the items that make sense.

In summary, I want to leave you with four strong personal convictions about this program:

First, Space Station Freedom, I think, is extremely important for our Nation, for our space program will be the cornerstone of our programs, our science programs, technology, and exploration for the next three decades. But the national benefits of this program extend down from space right here on Earth. Education, technological competitiveness, the environment—these are just a few of the things that will be affected.

Second, as President Bush said, "Our commitment to leadership in space is symbolic of the role we seek in the world." Our leadership in space will not go unchallenged. The future will belong to those who prepare for it, and I don't have to tell you that space plans of other Nations are ambitious. And I am not speaking only of just the Soviets.

Third, our plans for the Space Station Freedom are well laid. We know why we are building the station. We know what are going to use it for. We have the right configuration, and we have our international partners on board. Because a substantial national investment in this program has already been made, we have made real progress.

Finally, cutting corners is inefficient and poor stewardship. Underfunding Space Station Freedom would slash into its capabilities and increase the program risk. Any near-term deferrals and development costs will end up in increased development costs and also increased operational costs.

I can't resist the temptation to quote OMB Director Richard Darman on this subject. In response to a question from Congressman Buechner in a hearing last week, Mr. Darman said, "The only way to obtain significant on-the-dollar savings from the NASA budget would be to cut into the space station and stretch it out. That would be tantamount to killing it, and I don't want to do that."

He also said that, "Investment in space is an investment in the future benefits. It's good policy and it's good budget."

Space Station Freedom is possible because we as a Nation made earlier investments in people and programs and the scientific instruments; without this sustained NASA infrastructure this program and future programs will not be possible.

In closing, let me just say that when we—the Administration, the Congress, and the Nation—chose to go ahead with Space Station Freedom, we made the right decision for the right reasons. We must not back away from this commitment. We have an unavoidable responsibility to prepare for the future and its challenges. The Space Station Freedom, I believe, is an essential part of the American future.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Odom follows:]

National Aeronautics and
Space Administration

Hold for Release Until
Presented by Witness

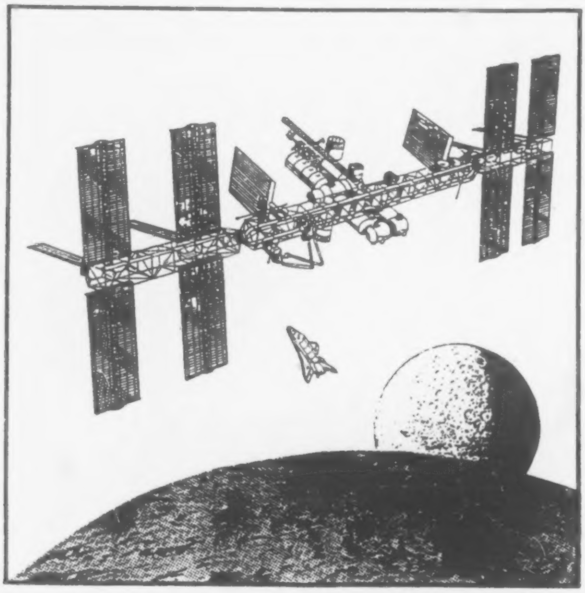
February 28, 1989

Subcommittee on Space Science and Applications

Committee on Science, Space, and Technology

House of Representatives

Statement by:
James B. Odom
**Associate Administrator
for Space Station**



101st Congress

Mr. Chairman and Members of the Subcommittee,

I welcome this opportunity to discuss the Space Station Freedom Program with you. This morning I would like to review our recent accomplishments and describe program efforts now in progress, then summarize NASA's fiscal year 1990 Space Station Freedom budget request and identify the activities planned for this time period.

Let me begin, however, by emphasizing that the reasons why our nation is building Space Station Freedom are now more relevant than ever. Last year's successful return-to-flight of the Space Shuttle was an important step toward reinvigorating American leadership in space. With Space Station Freedom, safe and effective operation of the space shuttle, and programs such as the Great Observatories, we are ensuring that the United States maintains this leadership through the late 1990s and well into the next century.

A permanently manned base in orbit is vitally necessary for our nation to sustain this leadership and to continue reaping its associated wealth of benefits. The importance of this program has been repeatedly recognized in Presidential and Congressional decisions to proceed with Space Station Freedom and keep the program on track. President Bush reiterated this recently when he said, "We must have a manned space station... the space program should always go 'full throttle up.' That is not just our ambition; it is our destiny."

The benefits of our leadership in space and federal investments in space research and development have been very tangible - they have enhanced our national science and technology base and contributed to our economic well being. As an investment in the future, Space Station Freedom is no exception. I am convinced that people will play a productive role in space, just as they do on Earth. The capability to live and work in space laboratories and workshops on a continuous basis, 365 days a year, will result in significant benefits.

Space Station Freedom is the next step in the development of our national space infrastructure. Just as railroads played a central role in opening the American frontier for development after the initial exploration, this infrastructure will be the foundation to open the frontier of space for development.

As a cornerstone of this infrastructure, Space Station Freedom complements capabilities and objectives across all parts of our space program. For our science program, Freedom offers platforms for instruments to look out at the universe as well as back toward the Earth, and a laboratory for research in many scientific disciplines. Long term operation on the manned base or its associated platforms will be a natural growth path for scientific experiments developed on the ground and flown on the Space Shuttle or privately developed facilities. For technology development, Freedom will be a unique national facility - a testbed for evaluating technologies, procedures, and design approaches for potential application in future space systems. Technology benefits may even begin to flow before Freedom is operational in such important areas as control of large space structures, power generation, automation and robotics, and environmental control. For our exploration program, Freedom's manned base represents the establishment of a permanently manned outpost in space.

Freedom will initially be most valuable as a space workshop, laboratory, and viewing platform. As our leadership and vision continue and as national requirements are defined, it can evolve to accommodate other potential roles: a "construction facility" for assembling large space structures, a "service station" for satellite refueling and repair, and a "production facility" for unique materials and substances.

The long term goal of expanding human presence and activity beyond low earth orbit requires the space station for potential missions to the moon, Mars, or other parts of the solar system. Initially, we will use the manned base to study the long-term effects of the space environment on people to prepare us for the potential missions of the future. Before we take this step, we must understand the effects of weightlessness in humans, and develop countermeasures to prevent any detrimental effects. Freedom may one day be our waystation in orbit, a staging area for manned expeditions venturing out from our home planet to explore other parts of the solar system. No matter what major objectives we choose for the early 21st Century, Freedom is a necessary stepping stone. NASA's Office of Exploration succinctly captured the importance of this fact in a single phrase in its 1988 Annual Report: "All roads begin with Space Station Freedom..."

When our presence in space matures from short visits to prolonged stays, the inherent nature of research in space will change, facilitating not only the normal process of scientific investigation, but also the totally unexpected - and sometimes serendipitous - discoveries that have historically been so important to technological advancement. Moreover, the human innovative spirit will be unleashed from the constraints of limited time and experience in this new environment. Advances in space technology, materials science, life sciences, and biotechnology will probably be the first visible dividends we earn, but there will be many, many more.

The program will have a positive motivational influence on education. Freedom's high public visibility and our educational programs will revitalize interest by our young people in science and engineering careers. Furthermore, the capability to conduct rapid response experiments in reaction to new ideas and research opportunities will have a positive impact on university students and researchers, particularly those pursuing advanced degrees. All of these factors will act to strengthen our national technological competitiveness and long-term economic well-being.

At a higher level, Space Station Freedom will offer benefits that transcend the objectives of any single nation. Freedom will not only become a global focal point for space research, it will also help us better understand the world in which we live.

This role becomes increasingly important as world interest in global environmental changes grows more urgent. Space Station Freedom's capabilities will support the U.S. Global Change Research Program to examine closely the impact of environmental changes on our planet. Global problems such as deforestation, desertification, ozone depletion, and climatic shifts will be studied by instruments on both the manned base and its associated polar platforms.

When President Reagan called for the development of the space station, he invited international participation to strengthen peace, build prosperity, and expand freedom for all who share our goals. After three years of intensive negotiations, our partners (Belgium, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Spain, and the United Kingdom) are providing major program elements estimated to cost nearly $8 billion, making Freedom an unparalleled effort in international science and technology cooperation. At the Intergovernmental Agreement signing ceremony last year, former Secretary of State George Schultz noted that "this project also will be a shining symbol of the commitment of those who place a high value on political and economic freedom to cooperate for mutual benefit."

President Bush, like President Reagan, recognizes that space holds enormous potential for commerce. He supports private sector investments in space with specific policy guidance and instructions. We are actively seeking private sector involvement in the program through two distinct avenues: commercial utilization of Space Station Freedom and commercial provision of program-related infrastructure. The innovative strengths of American industry can make a substantial contribution to our space activities. This will be covered in more detail later in the testimony.

We have already made significant progress toward achieving the objectives I have described thus far. A strong management structure, tailored to handle the complexity of the Freedom program, has been established. We have confirmed that our configuration is the correct one to meet our national objectives. Freedom's team of contractors, most of whom have worked on the program for four to six years, is now engaged in design activities. Last, the program is on schedule and projected costs remain unchanged.

It is essential that Space Station Freedom program activities continue to be fully funded if our early efforts to build a proper program framework are to result in substantial savings in the years ahead. Total life cycle cost factors are at least as important as development costs in design decisions. Similarly, we will continue to place a strong emphasis on ensuring that user needs are addressed during the design process. These early efforts, which will later enable us to achieve the maximum benefit from Space Station Freedom for the lowest reasonable cost, must continue unimpeded.

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Program Status: Recent Accomplishments and 1989 Activities

I would now like to move on to our recent progress and ongoing activities.

An effective development structure for the Freedom program is now in place. Last September, NASA signed contracts with the four work package prime contractors. Boeing is working with the Marshall Space Flight Center to develop the U.S. pressurized modules and logistics elements. McDonnell Douglas is working with the Johnson Space Center to develop the central truss structure, resource nodes, and various flight systems. General Electric is working with the Goddard Space Flight Center to develop the Polar Platform and attached payload accommodations on the manned base. Rocketdyne is working with the Lewis Research Center to develop elements for power generation, storage, and distribution.

To enable the long-term intersite delivery process and to reduce program risk, Associate Contractor Agreements have been instituted among these companies. These agreements facilitate direct interaction in resolving detailed interface and scheduling problems before products are delivered. The resulting increase in efficiency will minimize costs, reduce program risks, and allow better use of resources.

We also have in place three contracts that are important components of the development structure required to successfully address the complex management and technical issues of the program. These efforts, managed by the Space Station Freedom Program Office in Reston, are just as essential to the success of the program as the development contracts.

The Program Support Contractor, Grumman, performs critical systems engineering and integration tasks for the program office. This contractor also plays key roles in supporting program management processes, in laying groundwork for operation planning, and in interactions with the user community.

Lockheed is developing the Software Support Environment, an integrated set of standardized software "rules and tools" that will simplify the development, operation, and maintenance of computer programs used in both flight and ground systems over the life of the Freedom program.

Finally, Boeing is developing the Technical and Management Information System. This system and associated services will provide a conduit and storage resource for the virtual flood of information that will flow among hundreds of organizations during Freedom's development and 30-year life.

An intensive review by the National Research Council in 1987 confirmed that our baseline configuration is the best design suited to meet the overall requirements. The report stated that the configuration "reflects the thoughtful compromises among the priorities and sometimes conflicting requirements of its early scientific and engineering users." Last year we formally defined space station system and element requirements so that preliminary design activities could begin. A program-wide requirements review, held in the early summer, was followed by more detailed requirements reviews at the NASA Centers responsible for the four work packages. The objective of these efforts was to ensure that critical design requirements throughout the program were identified, quantified, and reflected consistently in documentation at all program levels.

With these important milestones behind us, our development efforts are now underway. The four NASA work package centers and their prime contractors are now heavily involved in design activities for their assigned Space Station Freedom elements and systems.

Our advanced development program for some critical hardware is beginning to show some return, and we are seeing tangible results. Prototypes of the rotary joints that will point the solar arrays and thermal radiators have been fabricated by Honeywell and delivered to Johnson Space Center for testing. A prototype of the control moment gyroscope needed for attitude control was built by Allied-Signal and will shortly undergo life testing at Johnson Space Center to verify the design and evaluate new features. Substantial work has been performed by Marshall Space Flight Center and its contractors on the environmental control and life support system. Selected elements of this system have been built, several new technologies for waste management have been developed, and tests are now in progress to measure their effectiveness in an environment similar to that planned on Freedom. In the area of automation technology, Goddard Space Flight Center is continuing its work on advanced robotic manipulators. At the Lewis Research Center, nickel-hydrogen batteries are undergoing life cycle tests to provide data needed for their use on Freedom. Testbeds to demonstrate the operation of a 20KHz power management and distribution system have been built. Hydrogen/oxygen thrusters and resistojet thrusters are also being tested.

Utilization and operations planning is an extremely important ongoing process in the design of the station because it ensures that user requirements are properly incorporated and that the manned base and polar platforms can be effectively operated over the long term. Working together with the user community and our partners, we are defining the detailed requirements for a wide variety of user activities. Workshops were held last year to exchange information on science operations, user accommodations, ground processing and related topics. On-orbit operations and maintenance concepts are being defined to influence system design. Additionally, long term logistics support has been incorporated as a major driver in system design and acquisition decisions.

Two important facilities for Space Station Freedom were recently completed to support ongoing hardware development efforts. The Space Station Mockup and Integration Facility at Johnson Space Center was dedicated in November. The Power Systems Facility at Lewis Research Center was dedicated this January.

In September, the U.S. Secretary of State and representatives of Belgium, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Spain, and the United Kingdom signed the Intergovernmental Agreement covering cooperation in the Space Station Freedom Program. This monumental agreement will be the foundation for three decades of international space station activities. Robert de Cotret, who signed the agreement on behalf of Canada, aptly stated, "today is the fusion of two modern trends as one, when several nations agree to work together in the peaceful exploration of the universe that surrounds our globe. In doing so, we make for a better world here on Earth."

NASA also signed separate bilateral Memoranda of Understanding with the European Space Agency and the Canadian Ministry of State for Science and Technology that focus on programmatic and technical aspects. We will sign a similar agreement with Japan this spring. These agreements, coupled with the strong budget commitments of our international partners, represent long term commitments to the success of this program.

With the negotiations behind us, we have moved to the implementation phase of the cooperation. We are working with our partners to establish the management mechanisms created in the Intergovernmental Agreement and the Memoranda of Understanding. We are also developing the second-tier documentation called for in our agreements. Our partners have established liaison offices here in the United States, and we are completing the establishment of similar offices in our partners' countries. These liaison offices are critical to working with our partners effectively and efficiently.

Earlier this month, NASA announced the selection of scientific investigations for definition in the Earth Observing System program. This effort to study global environmental changes will utilize instruments on polar orbiting platforms, beginning with the Space Station Freedom Polar Platform. The selected teams' activities will involve 551 investigators from 168 institutions, universities, and laboratories in 32 states and 13 nations.

To encourage and promote commercial participation in Space Station Freedom infrastructure, we released draft policy guidelines, procedures, and criteria for industry review last October. This document will be revised and formally issued after industry comments are received this year. Additionally, in 1989 we plan to establish a process for identifying future space station requirements that could be commercially provided, along with implementation mechanisms consistent with Administration policy and procurement regulations .

In November, we co-sponsored with the Office of Commercial Programs our second successful workshop on commercial opportunities in the Space Station Freedom Program. Potential opportunities in materials sciences, remote sensing, life sciences, and infrastructure were discussed with 150 industry representatives. This workshop will be held annually.

We are still on schedule for all major program milestones, including the first element launch in the first quarter of 1995, man-tended capability in the fourth quarter of 1995, permanently manned capability in the fourth quarter of 1996, and assembly complete in the first quarter of 1998. These dates are the same as those presented to you last year.

Finally, I want to note that our estimate of total runout costs for the Freedom development effort remains at $13 billion in 1984 dollars. In summary, the program has stabilized. The configuration has been set since 1987, and our cost estimates and schedules remain the same.

We have been able to maintain our schedule and cost plans only because Congress and the Administration have strongly supported the build-up in funding levels that is essential to a program of this scope. You demonstrated this support last year when you approved a three year authorization for the Freedom program. Your continued support is absolutely imperative if Space Station Freedom is to be built cost-effectively and on time.

* * * * *

Budget Request For Fiscal Year 1990

The funding required for Space Station Freedom in FY 1990 represents a substantial increase over this year's funding. This increase is necessary if we are to design and build the right station, on schedule and at the overall funding level we have set. To support the design process that is now underway for most Freedom elements and components, our contractors' engineering work force must be expanded considerably, and subcontractors must be brought on board as planned. In addition, ground facilities required for testing, training and integration must be completed in order to support the schedule. Total aerospace-related jobs associated with the Space Station Freedom Program are estimated to increase from 15,000 to 32,000 across the country.

$2.050 billion is required to keep the Space Station Freedom Program moving forward in FY 1990.

Of this total, $1.556 billion will go to the four work package centers in order to pay for the required buildup of development activities at the four prime hardware contractors and their subcontractors. The NASA centers will continue to use their expertise and facilities for supporting development activities such as test bed construction and operation, in-line hardware development and supporting analyses, safety reviews, and quality assurance.

$184 million will go toward operations and utilization capability development. This effort includes the design and development of equipment, facilities, and capabilities required to operate and use Space Station Freedom efficiently and effectively.

$230 million will be spent to integrate the program's management and technical systems, to perform systems engineering, to coordinate activities with our international partners, to implement a software environment directed at controlling software costs, and to enable other program control and support activities.

$15 million will be spent on the Flight Telerobotic Servicer (FTS). Consistent with Administration policy, NASA is exploring private investment in development of the actual flight hardware, so the funds we request at this time are only for activities at the Goddard Space Flight Center that support development.

$25 million will be required for the Transition Definition Program to ensure that Space Station Freedom is designed to easily incorporate new capabilities to enhance utility, improve efficiency of on-board operations, support commercialization efforts, and meet future national objectives.

$25 million will be needed for Operations. Although some planning for operations is ongoing within the development program to ensure that user requirements are adequately addressed in the space station design, FY 1990 is the first year that funding is required to plan for integrated logistics operations and space systems operations in the program's actual operations budget.

Finally, $15 million is required for a new item in the program, a radar system to detect and monitor orbital debris. This effort, funded by NASA's Office of Space Flight prior to FY 1990, will provide data needed to ensure that the Freedom manned base will be adequately protected from debris impact.

In addition to the funding I have just discussed, the Administration proposes legislation for a three year advance authorization and appropriation of $8.5 billion covering FY 1990, 1991, and 1992. A program development cost ceiling of $13 billion in 1984 dollars is also proposed. This legislation would, by increasing programmatic stability and continuity of funding, facilitate resource planning and improve the cost-effectiveness of the development process.

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Activities Supported By FY 1990 Funding

Let me now move into the specifics of what we must accomplish in FY 1990 to maintain our goal of launching the first elements of Freedom in the first quarter of 1995. I will first describe development and supporting development activities for the four work packages, then move on to other work planned for FY 1990.

Work Package 1

Marshall Space Flight Center and its prime contractor, Boeing, will complete preliminary design of Work Package 1 elements and systems. These include the U.S. laboratory module, the habitat module, logistics elements, the environmental control and life support system (ECLSS), the resource node structure, and internal components of the audio/video and thermal control systems. Preliminary design reviews on these items will be conducted to allow final design activities to get underway.

Boeing will also complete comparative testing of ECLSS technology demonstration hardware and will begin testing in the Core Module Integration Facility, a full-scale mockup of the U.S. laboratory module. Work on resource nodes and airlock systems will focus on component testing of support equipment, preliminary design of the cupola, tool and production planning, and material procurement for structural test articles. Boeing will complete the U.S. laboratory engineering development article, and fabrication and test of development hardware and software will begin. Preliminary design of functions unique to the habitation modules will continue, as will the review of cargo requirements for the logistics modules. Concepts will be developed for the accommodation of specimens, carriers, and subsystems. Development testing for logistics-unique hardware and definition of logistics module interfaces with the cargo, Orbiter, and space station will continue. Neutral buoyancy facility tests will be performed to evaluate and verify man-systems interfaces. The critical design review on the node structural test article will be conducted, leading to the start of fabrication.

Marshall Space Flight Center will continue its supporting development efforts. Breadboards (hardware assemblies of preliminary parts used to prove hardware feasibility) will be used for development testing for the process-material management system, the audio-video system, and the electrical system. By the end of FY 1990, most of the supporting development testing will be completed and the prime contractor can begin building flight-design hardware for qualification testing.

Work Package 2

Johnson Space Center and its prime contractor, McDonnell Douglas, will complete preliminary design of Work Package 2 elements and systems. These include the central truss structure, mobile transporter, propulsion system, outfitting of resource nodes, airlocks, guidance, navigation and control system, external components of the thermal control system, communication and tracking system, data management system, and systems for extravehicular activity. Preliminary design reviews on these items will be conducted to allow final design activities to get underway.

McDonnell Douglas will also continue development testing and begin procurement, fabrication, and assembly of data management system hardware and software, the thermal control system, the mobile transporter, and the airlocks. Development of the propulsion system electrolysis unit, propellant tanks, and thrusters will be initiated.

Johnson Space Center will continue its supporting development efforts. Integrated loads/dynamics analysis of the Freedom truss structure will begin, a thermal vacuum chamber will be outfitted for solar simulation, and verification testing of the TDRSS on-board antenna will be conducted.

Fabrication and test of the propulsion system water electrolysis prototype will continue, and refinement and testing of an advanced space suit will be completed. Tests requiring a zero-gravity environment will be carried out on the KC135 aircraft, which can provide short periods of low gravity test time.

Work Package 3

Goddard Space Flight Center and its prime contractor, General Electric, will complete preliminary design of Work Package 3 elements and systems. These include the U.S. Polar Platform and attached payload accommodations, including a payload pointing system. Preliminary design reviews will be conducted to allow final design activities to get underway.

General Electric will also continue studies of servicing facility architecture, and will develop servicing scenarios for selected payloads located outside the pressurized modules.

Goddard Space Flight Center will continue its supporting development activities. The effects of space station motion on the payload pointing system will be studied. As part of the attached payload and polar platform thermal control program, development of a data management system test bed and an instrument test bed will continue, as will design of several experiments planned for flight on the Space Shuttle. Requirements definition and design of the planned Integration, Test and Verification Facility will be initiated. This facility will provide a clean environment for the check-out of attached payloads and the polar platform with the appropriate physical, electrical and thermal interfaces.

Work Package 4

Lewis Research Center and its prime contractor, Rocketdyne, will complete preliminary design of Work Package 4 elements and systems. These include power modules and other parts of the electrical power system. Preliminary design reviews will be conducted to allow final design activities to get underway.

Rocketdyne will also continue development and qualification of photovoltaic cells and substrate blankets. Qualification nickel-hydrogen energy storage assembly cells will be fabricated and tested. The preliminary design effort for the solar dynamic power system will continue. Development and testing of the 25 kW, 20kHz primary distribution breadboard and brassboard will continue.

Lewis Research Center will continue its supporting development efforts. Prime contractor systems engineering and integration efforts will be independently verified. Work on the photovoltaic power generation and storage and power management and distribution elements will continue, using several existing testbeds, and an integrated testbed will be built. Activities to support the solar dynamic power development effort will include thermal-vacuum testing of an advanced development heat receiver and optical testing of a solar concentrator.

In addition to the activities I have just described, each work package will be involved in many other significant activities. Continuous update of interface control documents will be crucial as system and system component designs mature. Each work package will also support development of the distributed systems that interface across more than one work package. Procurement of long lead items will also begin.

Operations / Utilization Capability Development

This effort spans activities at several NASA centers. The Program Office will continue to develop the tactical planning capabilities required for integrated operations and utilization activity planning during the assembly and operations phases.

The Kennedy Space Center will continue to develop capabilities for pre-launch and post-landing ground operations. Equipment for computer-aided design and computer-aided engineering will be procured, design of the Test, Control, and Monitor System will continue, and equipment for the Space Station Processing Facility will be procured. Marshall Space Flight Center will continue developing user integration capabilities. Design of the Payload Operations Integration Center and the Payload Operations Training Facility will continue, and analytical integration software tools will be developed. Johnson Space Center will continue to develop capabilities for operational control of Space Station Freedom. Design of the Space Station Control Center and the Space Station Training Facility will continue. Goddard Space Flight Center will continue user accommodation studies.

Each of the NASA Space Station Freedom development centers will also continue design of an Engineering Support Center to provide technical expertise during the assembly and operational phases of the program.

Systems Engineering, Integration, and Management

A program-wide preliminary design review will be conducted in the summer of 1990. In preparation for this review, the Program Support Contractor, Grumman, will conduct numerous integrated systems analyses to support the establishment of detailed design requirements for the work package contractors and the evaluation of end-to-end performance of their designs when integrated together into the space station.

Specific analytical efforts will include combined loads analyses, combined thermal system loading and performance studies, and assessments of the natural and induced particulate and electromagnetic environments around Space Station Freedom. The performance and interaction of designs for all distributed systems will be analyzed for each of the twenty on-orbit assembly sequence configurations as well as for contingency situations.

The Program Support Contractor will also play a key role in the development of program plans for launch package integration, on-orbit assembly and checkout, mission planning and integration, system safety plans, and quality assurance plans.

Operations

As the Space Station Freedom Program matures, elements of the development program (including operations/utilization concept development) will transition into components of the operations program. This transition will begin in FY 1990. Initial planning for integrated logistics operations will focus on logistics management, maintenance planning, and early planning for initial spares. Space system operations activities will include the study and integration of assembly planning tasks.

Transition Definition

Because Space Station Freedom will have an operational lifetime of 30 years, which is unprecedented for a space system, it must be designed to adapt to support evolving user needs. Moreover, elements and systems must easily accommodate future technology advances to enhance productivity, reliability, and safety as well as to avoid obsolescence. For this reason, evolution planning and advanced technology development have already begun.

Evolution planning has already resulted in better definition of the resource requirements and primary design features (software hooks and hardware scars) required to accommodate evolution in the baseline design. In FY 1989, we are focusing on probable evolution paths and their impact on detailed hooks and scars in distributed systems. In FY 1990, we will begin feasibility studies on a reference configuration, and will identify the technologies necessary for evolution. We will also fund development work on the application of knowledge-based system technology to management of the distributed systems on the station. Other tasks will focus on automation technologies that could be applied to Space Station Freedom early in its operational lifetime. We will also continue to expand the efforts in planning for commercial participation in the space station.

Orbital Debris Radar

The development of the orbital debris radar will begin in FY 1990. This ground-based radar is required to gather new data on the orbital debris environment in which Space Station Freedom will operate. Since orbital debris is a potential threat to all space systems, accurate characterization of this environment is a necessary input to the design of the pressurized modules. The orbital debris radar, unlike existing radars, will be able to track debris between one and ten centimeters in diameter. The Jet Propulsion Laboratory will manage the development of the required hardware and software, which will be developed under a competitive contract.

Flight Telerobotic Servicer

NASA is currently reviewing proposals from two companies, Martin Marietta and Grumman, for development of the FTS. Contract award is planned for June 1989. The FY1990 budget for FTS assumes that NASA will seek private sector investment in system development. However, NASA will continue its supporting development and integration activities.

Contractor activities in FY 1990 will focus on two near-term test flights planned for the Shuttle. Detailed design of equipment for the early telerobotics demonstration test flight will be conducted, and preliminary design activities for the early development test flight and the Space Station Freedom flight article will begin.

Goddard Space Flight Center and other NASA centers will continue their supporting development activities. Applicable new automation and robotics technologies will be selected to improve FTS performance.

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I would now like to address two other issues associated with the FY 1990 budget request.

Commercialization

The NASA commercialization initiatives proposed by the Administration support national space policy and commercial space initiatives. President Bush reinforced the U.S. policy objective of more commercial development in space in his State of the Union message on February 9.

The specific commercialization initiatives for the Space Station Freedom Program include the FTS, the Space Station Processing Facility (SSPF), the Neutral Buoyancy Laboratory (NBL), the docking module, the logistics system, and potential enhancements like solar dynamic power.

The SSPF at Kennedy Space Center will be used for preflight processing of manned base hardware and both preflight and postflight processing of logistics elements. The SSPF was selected because of its potential for synergy with commercial proposals being considered by NASA in the area of logistics services. The private sector has already shown interest.

The NBL at Johnson Space Center will include a very large underwater working area for developing and practicing manned assembly approaches for Space Station Freedom. Existing facilities are too small to support the extensive activities planned. The astronauts who will assemble and maintain the manned base require intensive terrestrial training and preparation to maximize the safety, efficiency, and effectiveness of operations in space. The NBL was selected for commercialization because of its potential for long-term use by space station users and for terrestrial applications. The private sector has already shown interest. Potential commercial applications include preparation for undersea construction and maintenance activities, including those involved with offshore oil drilling.

The space station docking module was selected because commercial entities have indicated interest in developing it or are developing similar systems.

We will continue to explore ways to commercialize elements of the logistics system. Private sector proposals to participate resulted from our inclusion of the commercialization concept in the space station requests for proposals. We will continue to review with the Administration any significant issues that may arise.

The solar dynamic power enhancement for the space station could allow domestic firms to receive payment for the provision of power in space and to protect their technology for future applications.

NASA has been working on the development of specific criteria, guidelines, policies, and procedures to facilitate and encourage commercialization. These have been recently released for industry comment. We certainly seek Congressional views as well.

It must be recognized, of course, that commercialization decisions should consider the nature of the project involved, the stage of procurement, the nature and scope of commercial proposals, and resulting benefits to the government. Consequently, we will need to maintain flexibility in developing approaches to commercialization.

It should be noted that foreign competitors are moving ahead in space commercialization. Foreign companies, often in cooperation with their governments, are making investments to obtain financial benefits in the future. In Japan, for example, it is widely predicted that its space industry will be as important to its national economy in the future as its electronics industry is today. We in the government should be encouraging American companies to invest in our economic future in space as well.

The Space Station Manpower Problem

NASA's FY 1990 budget includes Research and Program Management (R&PM) funds for salaries of additional civil servants for Space Station Freedom. As the efforts of the space station contractors expand, NASA direction and oversight must also grow to ensure that Research and Development (R&D) funds are spent wisely and efficiently. The additional personnel requested for FY 1990 are required if we are to continue the strong management role necessary for effective systems engineering and overall direction of this international program.

In FY 1989, the Administration approved an agency-wide, multi-year staffing augmentation plan that included 725 additional civil servants to support the program at Reston and the work package centers. Our plan is to accommodate an initial increment of this augmentation in NASA's FY 1989 operating plan. NASA's FY 1990 R&PM request must be fully funded to adequately meet space station staffing needs.

* * * * *

Conclusion

In closing, I want to leave you with four important thoughts.

First, Space Station Freedom will result in a broad spectrum of benefits to the United States. Freedom is not a mission in itself. Instead, it is a unique capability that will yield significant technological, scientific, economic, social, educational and foreign policy benefits. Freedom is a vital piece of the space infrastructure our nation needs to support science, technology development and exploration efforts. We will depend on this valuable resource for decades to come. *Our investment now will pay tremendous dividends later.*

Second, our leadership in space will not go unchallenged. The future will belong to those who prepare for it and are committed to it, and the long term space plans of other nations are ambitious. Our commitment to Space Station Freedom is a commitment to U.S. space leadership, As President Bush so aptly stated, *"our commitment to leadership in space is symbolic of the role we seek in the world".*

Third, our plans for Space Station Freedom are well-laid and our program is stable. The right management and development structure is in place. We have the right configuration given our objectives and funding constraints, and we have already made a significant national investment in its implementation. Our international partners are fully committed to their parts of the program. *We have made substantial progress and are well on our way.*

Last, cutting corners would be poor inefficient. Our budget for FY 1990 is just barely adequate. Underfunding Freedom at this critical phase of the program would reduce its performance, and thus its usefulness. At the same time, *it would increase program risk, and increase total long term costs.*

When we, as a nation, chose to proceed with Space Station Freedom, we made the right decision for the right reasons. We cannot back away from our commitment to this endeavor, for it is too important to our future as a space-faring nation. The American space program has proven over the past three decades to be among our wisest investments, inextricably linked not only to the economic welfare and vitality of our country, but also to the nurturing of our national spirit. We have an unavoidable responsibility to look to the future and its challenges, and Space Station Freedom is an essential part of the American future.

We must stay on track.

Mr. NELSON. Mr. Odom, for our members, many of whom are new members and are quite excited about this project, let's take the model here and let's point out to them first of all, I think it's important for the members to see the relative size here. You know the size of the Orbiter, which is the size of a stretch DC-9. So, you can see the relative size of the actual truss here.

Will this generally be relative to the Earth in that configuration?

Mr. ODOM. That's correct. It will be flying basically toward you.

Mr. NELSON. The Phase II, will that include a boom that goes in the vertical position?

Mr. ODOM. In both directions, above and below. That's correct.

Mr. NELSON. Then, for the members, you can see the manned modules are here for the two United States and Japan and the ESA module connected by these.

What are your connectors called?

Mr. ODOM. Nodes.

Mr. NELSON. Each of the nodes, here is one that has an observation kind of—what do you call that?

Mr. ODOM. A control tower. It will control the traffic in and around and activities immediately adjacent to the station.

Mr. NELSON. The space shuttle will have a special docking adaptation. It will come in for the duration of the space shuttle. It is visiting the station; it will remain docked.

Now, where is the telerobotic arm that you all are having considerable discussion on? Is it this one that moves up and down the truss?

Mr. ODOM. That's correct.

Mr. NELSON. This is designed so that it can lessen the EVAs or extravehicular activity by the astronauts?

Mr. ODOM. That's correct.

Mr. NELSON. So that you do things automatically.

Mr. ODOM. That's correct.

Mr. NELSON. Where is the little garage on here that you repair satellites and repair any other spacecraft?

Mr. ODOM. That comes with the next phase.

Mr. NELSON. All right.

Now, we do not have the solar dynamics, which is the new form of electrical production. This is the normal photovoltaic solar cell arrays.

What are these panels right here?

Mr. ODOM. Those are radiators for ejecting excess heat.

Mr. NELSON. Why don't you tell us about each of the modules here, the two for the United States, the one for ESA and Japan.

Mr. ODOM. The one nearest Congressman Sensenbrenner there is the laboratory module. That will be our U.S. laboratory. The one immediately toward me, that one, is the habitation module. This is basically the living quarters.

As Congressman Nelson said, the two on the other side are supplied by the Japanese and also the Europeans.

You will notice a unique difference between those two. The Japanese is a shorter version of the module with basically a back deck on it for exposed experiments, along with the robotic arm which will be used to service those experiments.

The European module is basically a pressurized module or laboratory very similar to the U.S.'s in size.

Mr. Nelson. What are those kinds of modules that are on top of the Japan module and on top of the node that connect Japan with the United States?

Mr. Odom. The one on the Japanese module is also called the Japanese logistics module. That is, it will be supplied by them just as is their pressurized module. It is not totally clear at this point whether that will really serve as a logistics module or it will stay attached. Chances are it will probably stay attached to the Japanese module in the sense that it just increases the volume and capability of the Japanese module.

The other is what we call the cupolas, or the control towers. This is where you have visibility by one or two crewmen when the shuttle or other vehicles are approaching the space station to where you can actually control the traffic and control the operation and also from those you can see the extremities of the entire base.

Mr. Nelson. That is this here with the windows?

Mr. Odom. That's correct.

Mr. Nelson. What about this on top of the nodes in between?

Mr. Odom. That is an airlock. Literally if you bring in another unmanned or manned space station, a smaller one, you could dock to that and essentially do the pre-breathing and environmental conditioning before you go into another module.

Mr. Nelson. What are these panels?

Mr. Odom. Those are also radiators. Those are tied more to the power system where the larger radiators are tied for getting rid of the heat from the pressurized modules and also the experiment racks.

Mr. Nelson. Share with the committee what the free flier is.

Mr. Odom. That free flier is our polar platform. That is very much an integral part of the Space Station Freedom. Our program is providing basically the structural and the operating systems of that polar platform. The EOS experiments or the EOS program that will outfit that is controlled by the Office of Space Science and Applications, and they will provide the instruments that are attached to that platform.

Mr. Nelson. Since that is in polar orbit, what vehicle will launch the polar platform?

Mr. Odom. We will use the Titan ELV for the launch of that platform.

Mr. Nelson. The Titan IV?

Mr. Odom. That's correct.

Mr. Nelson. Any comments or questions from the committee about the overall basic structure, from anyone on the committee?

[No response.]

Mr. Nelson. All right.

Let's get on into some questions. We will start off with the members. Let's go to Mr. Sensenbrenner, then I will come to you.

Mr. Sensenbrenner. Thank you very much, Mr. Chairman.

First of all, I would like to ask unanimous consent that my opening statement be inserted in the record at the proper place. It just says that I firmly support the construction of the space station, and it commends the President for putting full funding in the budget.

Mr. **Nelson**. Without objection.

Mr. **Sensenbrenner**. Thank you, Mr. Chairman.

I would like to ask a few questions about the telerobotic servicer. As you know, I have generally been in favor of commercialization of various type of Government activity when commercialization is a viable alternative. I define a viable alternative as one that saves the Government money and, secondly, there is a buyer for the technology out there.

We found out there wasn't a buyer for the technology with the LANDSAT fiasco, which I hope we don't repeat.

The concern that I have with the telerobotic servicer being commercialized is that the only user is going to be the United States Government in the docking of the shuttle and using the telerobotic servicer to relieve the astronauts of doing a lot of work outside.

How do we save money by commercializing that when we are just going through one more level of middlemen and the Government is going to end up having to pay the freight for the telerobotic servicer plus the markup that would be caused by commercialization?

Mr. **Odom**. Congressman, I think the jury is a bit still out on whether or not you really will be able to save money on that. I think the jury is still out also on whether or not it truly is practical to commercialize the flight telerobotic servicer.

We have tried several options to try to make that work. We have not arrived at one at this date that makes a lot of sense to either us or the OMB. We are continuing to work that, but we are not at the point at this time to be able to tell you that we can or that it clearly can work.

Mr. **Sensenbrenner**. I recognize that commercializing the FTS will reduce the FY '90 budget because what we would be doing is shoving some costs for FY '90 off to the private sector, whoever wins the prime contract on that.

Has either NASA or the OMB looked at the total cost to the Government by the time we are done constructing FTS and the space station is up and the FTS is operational?

Mr. **Odom**. We have looked at it, Congressman, from the standpoint of the Government funding it, which is basically the baseline program.

As you may be aware, we are in the selection process right now for that piece of hardware. We have the proposals in. They are being evaluated, and it would be our intention to make that selection the first week in April and we will contract in June.

We do have estimates, and those estimates obviously will be fine-tuned as soon as we bring the contractors on board, construct, design, develop, and get hardware.

Mr. **Sensenbrenner**. How was this item selected for commercialization over other potential candidates?

Mr. **Odom**. I am not totally sure I know the answer to that, Congressman.

I think probably one of the reasons was—and I think it's rational—it's one of the things that is not on contract to date. So, as such, we should look at it.

I think that was primarily one of the reasons why it was selected.

Mr. SENSENBRENNER. I do know that two corporations have submitted bids for this. But that was before the decision was made to commercialize it.

Do you have any indication either from Grumman or Martin Marietta that they are going to have to modify their bids now that the playing field has been altered a bit?

Mr. ODOM. No, I do not. I have not talked to the contractors because we have not come to the point in the program that I would know how to modify the RFP and even ask if they would be in a posture to want to bid to it in a commercial vein. So, the answer to that is no.

Mr. SENSENBRENNER. It seems to me that with the schedule for the demonstration for this and the shuttle flights in '91 and '93, that if we delay too much on that, we are not going to make those demonstration targets. That could potentially delay this entire operation.

Mr. ODOM. You are absolutely correct. That also is one of the very difficult areas we are dealing with in trying to make this a commercial venture, because as you aptly indicated, we have a flight manifested in August of '91 and a second one in June of '93. To do those, we have already had to start some early design and development work even to accommodate those in the plan that we are on.

So, that would be, I think, very much a complicating thing.

Mr. SENSENBRENNER. Let me say that I appreciate your answers, Mr. Odom. Let me say that it is not your fault that your answers were not very specific. And it seems to me that whoever is making the decisions, the fact that we ought to commercialize certain parts of the space station is using a ouija board to decide which ones get commercialized.

It seems to me that before we go down the road of commercialization, we ought to be on solid ground that there will be a buyer for the product and also that it will save the Government money in its totality rather than just looking at the next fiscal year's budget.

One way the space station gets killed is due to huge cost overruns, and the way the huge cost overruns result is as a result of delay. It seems to me, from the information that I have, that we are building in delay and cost overruns by not knowing what we are doing on this issue.

That is why I think it is important that we find out what we are doing and do it quickly.

Thank you.

Mr. NELSON. What do you propose to have as an advantage instead of going the normal procurement process by this so-called commercialization process?

Mr. ODOM. I think one of the things—and let me just say that even though we are talking FTS, let me assure you that there are some things in commercialization, I think, that we should and will continue to pursue and will bring to fruition.

The one we are talking about right now, I think, is one thing that one could consider in doing this, is offering exclusive technology rights for what might come out of this development. That is one area that we are considering as potential leverage for a potential bidder.

Whether or not those technologies are such that they will fit the financial institutions or the companies that might want to bid it, or more specifically, as Congressman Sensenbrenner indicated, the two bidders that I am evaluating right now, whether that would fit their desires, I have no idea. But that is one thing that you might look at.

Another consideration would be other usage. But in this case, the principal user will be the Government. There will be some element, and some of the resources of Space Station Freedom that will be allocated to commercial users, but those commercial users get there through shuttle flights, through the basic system, through basically the Space Station Freedom program. So, the degree of truly commercial users for it, I think, would be extremely small.

Mr. NELSON. Let me return to Mr Sensenbrenner's ouija board. How did the ouija board, for example, select this, the telerobotic servicer, as being something you would want to commercialize instead of going through the normal procurement process?

Mr. ODOM. I don't think I know the answer to that, Mr. Chairman.

Mr. NELSON. How did the ouija board select, for example, the Boeing proposal for a logistics module?

Mr. ODOM. That one I can explain. In the RFPs, the requests for proposals that we went out initially for the Space Station Freedom prime contracts, we put into those RFPs requests for contractors that were bidding for the prime elements of the program to indicate interest or areas where they think it would be practical and desirable on their part to pursue commercial ventures.

The logistics module and the logistics support was part of the original bid, or at least the notion of that was a part of the initial bid by the Boeing Company in the Work Package one. So, that one basically came in through the initial RFP and is one that we are pursuing right now.

Mr. NELSON. Is this the logistics module here right now?

Mr. ODOM. That is correct.

Mr. NELSON. I take it Boeing made this proposal thinking that there are things that then if they had the exclusive rights to, that they could apply those technologies to other things?

Mr. ODOM. I don't think in their proposals they really reflected specifically technologies. In their proposal they had marketing rights for any excess. That was one candidate.

Another generic part of their proposal was to provide the services for both the loading and unloading of that during the operational phase of the period or from 1998 and beyond.

So, those were two of the kind of key elements of theirs that would have provided a revenue source over the years to come that would have offset their initial investments.

Mr. NELSON. Mr. Volkmer, do you want to follow up on that?

Mr. VOLKMER. Yes.

I would like to say, on the logistics module, from what you told the chairman, I understand the service to be performed by Boeing, who would be paying for those services?

Mr. ODOM. The program would be paying for it. The users would be paying for it.

Mr. VOLKMER. Who are the users?

Mr. **Odom**. In some cases it would be commercial. We have some resources that——

Mr. **Volkmer**. Mr. Odom, really, put it in percentage terms for me.

Mr. **Odom**. The larger percentage would be the Government.

Mr. **Volkmer**. That's correct. I think that is the whole thing. That has given us a lot of concern about it. When we talk about commercialization and what we are ending up doing is the Government is paying the bill.

Mr. **Odom**. The Government will be the dominant user of this, that's correct.

Mr. **Volkmer**. That gets me to something else, Mr. Chairman, I think some of us have been concerned with ever since we started on this and trying to get a handle on what we're doing. I think everybody wants that space station, but we would like to know what we're getting into when we get into it.

I appreciate the $13 billion developmental cost figure. But does anybody have any idea by 1998 when we have it operational, how much it is going to cost just to operate it?

Mr. **Odom**. Mr. Congressman, our estimate right now is in stable operation—and I would say you would probably want to add, take '98 and add a couple of years to let the operational program stabilize—in that neighborhood we would estimate the operational cost to be in the neighborhood of about $1.4 billion per year.

Now, part of that cost can be offset by some commercial use—I think that would be a relatively small percent. Also, part of it would be offset by the international partners. They would be paying basically 25 percent of the operating costs. When I say operating, I truly mean operating costs, the logistics costs.

I will have to say that is our estimate today. I think our estimates are pretty good. We continue to look at those. We have not seen any reason to change those estimates in the last two years. So, it gives me some confidence, but we have not designed the space station yet. We are in the process of doing that.

Mr. **Volkmer**. I understand that. That is based on what you have concepts of so far and the utilization of it.

Mr. **Odom**. That's correct.

Mr. **Nelson**. Did I hear you say 1998?

Mr. **Odom**. We will be operational in 1998, and what I was suggesting, you may want to operate it a couple of years before I would consider you are in a stable operational mode.

Mr. **Nelson**. Let me tell you, when we started getting serious about this, we were going to celebrate the 500th anniversary of Columbus' discovery of America with the operational status of the space station. Then that slipped, and it was going to be '94. And then '94 was going to be the first launch. And we were going to have it operational in '96. Now you're telling us it is going to be '98?

Mr. **Odom**. That's correct.

[The information follows:]

Space Station operations and utilization will first begin in 1995 with the establishment of man-tended capability. As the assembly of the manned base progresses and capabilities grow, operations and utilization will accelerate accordingly. The operational dates for Freedom have not slipped since Congress was officially informed of the latest schedule last April.

Mr. **Volkmer**. Mr. Chairman, I want to follow up on that. What I am concerned about, I have basically the same question before the '98 time frame. We have already seen some slippage in the timetable, correct?

Mr. **Odom**. That is correct.

Mr. **Volkmer**. What is the causation of the slippage so far? Design, et cetera?

Mr. **Odom**. I would——

Mr. **Volkmer**. If it is our fault, tell me so.

Mr. **Odom**. I would argue a little bit on the terms. A schedule slip is—on my ticket a schedule deferral is outside of something that I can handle, and I think the problem so far has been a noncommitment to the program and an inability to achieve the necessary funding in especially the years of '86 and '87 and '88.

'89? Last year we turned around. We started stabilizing the program and, as such, I think you will see that the program is stable. We are maintaining schedule, and I think it is on a good track now.

Mr. **Volkmer**. Thank you, Mr. Chairman.

Mr. **Nelson**. Well, we just simply have a problem with these kind of slips. I can just tell you that right now, and I want to get into the detail later on some questions there. But let me follow up.

You gave us the rationale of why the Boeing Company wants to commercialize that service module, but you did not give us the rationale for the telerobotic servicer because you said you didn't know.

Who does know?

Mr. **Odom**. That was worked between the agency and OMB, and we were looking at virtually elements of not only just the space station program but also other programs that might be handed to our commercial list that is being worked by our commercial office. That one came up as a candidate because it was not on contract. It was one that was still yet to be placed. I think it was between both the agency and the OMB that it was picked.

I will have to say, at the time that it was put on the list, it had not had much analysis that had gone into it as the basis of a selection, but we agreed that we would go off and try to see are there ways to make that work, and that is what we are in the process of trying to do now.

Mr. **Nelson**. Would the statement I am about to make have some resemblance to the truth? [Laughter.]

That the telerobotic servicer, the station mechanism, the station payload processing facility, the buoyancy tank, all have been submitted as commercial efforts in order to take them off the budget and therefore to keep the price?

Mr. **Odom**. That is very close to the truth. They were submitted as commercial ventures and they are not budgeted for.

Mr. **Nelson**. Without all of those things being budgeted for, starting from the time two years ago that we put $425 million plus the $900 million that is in the present, what would be the total cost?

Mr. **Odom**. I will give you that number in just one moment.

[Pause.]

The run-out, I will give you pretty close to the number, the one that is in my budget. The processing facility is approximately $84 million.

Mr. **Nelson**. Just give me the total. I am talking about the total for the whole station.

Mr. **Odom**. It is going to be about $120 million for the two facility items. I would prefer not to quote a number for the FTS because we are in an SEB process, if you don't mind.

The docking adapter is in Admiral Truly's budget, and I do not have that number. I don't know what that number is.

Mr. **Nelson**. All right. My question was, what is the total cost of the station less and except those items you just mentioned?

Mr. **Odom**. It will be several hundreds of millions.

Mr. **Nelson**. I am talking about the total cost, all that right there?

Mr. **Odom**. That right there is $13 billion in '84 dollars.

Mr. **Nelson**. $13 billion in '84 dollars. That includes this $900 million this year and $425 million last year?

Mr. **Odom**. That is correct.

Mr. **Nelson**. Are those figures you just gave me in 1984 dollars?

Mr. **Odom**. No, those are today's dollars.

Let me say one thing. We are a little bit mixing budgets here. The development cost of the $13 billion does not include sealed off costs, of which those would be outside of those. The same thing is true for the flight telerobotic servicer. It has been carried as a separate line item. So those would not be a part of the thirteen billion dollars.

Mr. **Volkmer**. I think, Mr. Chairman, we all recognize that, but what would it be with those two items?

Mr. **Odom**. The two facility items will be approximately $110 million more. That is the bottom line on that, and like I say, I would prefer not to quote a number, since we are in the selection process.

Mr. **Nelson**. Let me tell you, Dick Darman is one of the best in this town. He is one of the most inventive, fertile minds that I know. If this is his way of getting the cost of the space station down, my hats off to him. I am just curious if this is the way we ought to do it.

Mr. **Sensenbrenner**. Will the Chairman yield?

Mr. **Nelson**. I yield.

Mr. **Sensenbrenner**. Did I hear you just endorse voodoo economics?

Mr. **Nelson**. Was Mr. Darman the architect of voodoo economics?

Mr. **Sensenbrenner**. I don't know. [Laughter.]

Mr. **Nelson**. Mr. Rohrabacher.

Mr. **Rohrabacher**. A couple of questions just for information's sake.

Do you think the service module will be making some money for the Japanese at all? We have got a Japanese contingent here. Will you make a profit for them?

Mr. **Odom**. I don't think we will try to make a profit from them. They, along with the other two international partners, are investing about $8 billion into the program and, like year dollars to that $8 billion in '84, we are investing about twice that. They are making, like I say, about a 33 percent investment in the development cost of the program.

Mr. **Rohrabacher**. How much will they already have put up or when will they start?

Mr. **Odom**. They have already started. It is not our estimate. They have probably invested already in excess of $300 million, and beginning in this part of the program, which is about a third of what we have invested up until this point.

Also, they will—also, besides the development cost, they will be paying approximately 27 percent of the operating costs of the space station. So basically they pay their own way.

Mr. **Rohrabacher**. In exchange for that, we are letting them live in the modules?

Mr. **Odom**. That is right. That is part of the agreement. That is correct.

Mr. **Rohrabacher**. That is all I have. Thank you.

Mr. **Nelson**. Mr. Torricelli.

Mr. **Torricelli**. Thank you, Mr. Chairman.

Mr. Odom, I don't think you will find in Washington a group of people that are more enthusiastic about the space station than you would find in this room. We have invested a great deal of time, effort, and political capital on behalf of this project.

In fact, my colleagues and I a year ago wrote a letter to the leadership explaining that if this project were not fully funded and didn't proceed in a timely fashion we would oppose the entire federal budget, opposed at least by my party. That is how strongly we felt about it.

We want you to know, too, that what I have heard today has not done a great deal to maintain that enthusiasm on my part as one who believes deeply in this program.

Perhaps my colleagues have heard the 1998 date before. I haven't.

We are losing about two years for every year that passes. Indeed, based on the record of the last few years, there doesn't appear to be any reason to believe it is going to happen in this century. I don't understand that kind of management.

I know there have been problems with the funding. I know the funding hasn't been all that we have hoped for, but I think it is hard to justify, based on the difficulties of funding a few years ago, to have lost this kind of time.

Indeed, I would predict that by the time this space station is operational, I will bet that you will have consumed more time in delays than it took your entire predecessors to get from Alan Shepard to the man on the moon.

1998 and beyond, in my judgment, while there is an operational Soviet station and given the level of investment we have made, the national determination and the Presidential priorities that have been stated, from my judgment is not acceptable. I think it is an extremely poor statement on NASA today.

Second, I would like to endorse Mr. Sensenbrenner's and some of my other colleagues' comments. It appears to me that we are engaged in commercialization for the sake of commercialization. It is a pure and simple budget sleight of hand. It is a poor deal for the taxpayers in the long run and one in which during this authorization process, when we are involved in it next, I think that this committee should look at extremely closely. It is not right, it isn't fair, and it shouldn't happen based on everything I have heard so far.

In addition to that, several questions, if I might.

In addition to the fact that we have lost the capability to service satellites, I wonder in the change of configurations if you could explain to me on a scientific basis what other principal capabilities we have lost.

Mr. ODOM. Let me take your questions in reverse order.

When we went to the Phase I and Phase II configuration, Phase I being the one that you see, with the figures involved, and we removed the booms on those with quite a bit of ability to put outward looking instruments as well as downward looking instruments. So we did lose a good bit of capability.

Now, what we have done to try to minimize that impact, we do have two very large platforms that is on the base as you see it now that can both look up and look down. We have brought as much of that accommodation for scientific instruments looking out and down back to this original base program to minimize that hit.

We have also put in some early flights to actually do some early outfitting of the laboratory module in the first year of operation, in the first year of assembly, to take extra instruments and extra experiments, to get an early jump on the actual utilization from a scientific standpoint.

So we have tried to come back and backfill into the program and into the configuration capabilities to bring back as much of that science capability as we can.

Mr. TORRICELLI. Is there no principal practical scientific loss that should disturb this committee other than the satellite servicing capability?

Mr. ODOM. I can't say that. We lost some acreage. In other words, we cannot put as many instruments here as we could have before. I would say we are probably looking at maybe 20 or 30 percent of the capability that was in the original design.

Mr. TORRICELLI. Largely deep space observation monitoring?

Mr. ODOM. And looking back at the earth, also. That is correct.

Mr. TORRICELLI. In watching the scientific progress to date in research, are you convinced that the power requirements are going to be met by the advancement of the cells in the current engineering?

Mr. ODOM. The power will always be tight on this configuration, and I think it is something that we not only will be but we are watching very closely.

We also have the capability to add power to it. It is designed for it. We took off the solar dynamic systems. Those can be brought back.

We are continuing and we have money in the budget for the next five years to continue the systems development of the solar dynamic system, and we have the capability right now to bring that additional power on in the '97 time frame should we need it.

Mr. TORRICELLI. At this moment are we in balance with what you see are the power needs and the ability to produce that power, or are you dependent on continued technological advancement to achieve your balance?

Mr. **Odom**. No. I think the technology is there. Many of the subsystems have been built. It is a matter now of completing system tests and getting on into the design and the development of the additional power.

Mr. **Torricelli**. Some of your staffing problems some of my colleagues alluded to before. As I understand it, you filled 200 out of 378 civil service positions in your management center.

What is the problem?

Mr. **Odom**. The problem was actually we got OMB to agree with the additional spaces you have just alluded to last year. We have not quite figured out the mechanics yet of the funding to pay for those people. We hope we will sort that out in the next few months and can get on with that.

Mr. **Torricelli**. Two final questions if I could, Mr. Chairman.

Your comments, please, on the 25 percent ceiling that has been placed on the station and the current and anticipated levels of NASA funding that cause you considerable concern. Can you operate with it? Would you prefer to see it or not see it exist?

Mr. **Odom**. I assume you are referring to the ceiling up through May the 15th?

Mr. **Torricelli**. That is right.

Mr. **Odom**. We have adjusted the program for that. I can live with it. It is not the most efficient way to run a program. It is not the way I would have laid it out, but we are making the best of it.

Mr. **Torricelli**. Finally, the National Research Council has estimated, as many of us discussed on this committee, that there is an appreciable chance that between now and the end of the century another Shuttle will be lost or will be inoperable for a great period of time.

If we sustain the loss of another Shuttle, can you meet a 1998 time schedule? Is there room then in the fleet for your space station or would it need to await the construction of another Shuttle?

Mr. **Odom**. I am sure that were we to lose another Shuttle between now and then, if it happened early you might recover from it. If it happened late, I think it would have some impact.

Right now we depend on the Shuttle for a maximum of eight assembly flights a year during that-three-year assembly phase. In all those years that is the max, and with three Shuttle flights we would obviously consume the majority of the Shuttle fleet capability in doing the assembly of the space station. Either the space station would have to move or the other mission would go.

Mr. **Torricelli**. But it would be extremely tight?

Mr. **Odom**. It would be extremely tight.

Mr. **Torricelli**. If I could, a thought just came to mind. If you go to Phase II, if and when it should ever happen, in powering it, are you open to the idea of the reactor as a power source, or are you assuming we would just duplicate this kind of technology, and how great are the power requirements likely to be for Phase II?

Mr. **Odom**. You would be talking in terms of greater than an additional 150 kilowatts. The system is designed such that we could add additional solar dynamic systems to that very gracefully.

I think right now with today's technology that is where I am sure we would go. That you would assess when you get closer to that, but I would not be uncomfortable in doing that.

Mr. **Torricelli**. But my question on the reactor, is it not time to be honest with people and face the reality that at some point, given these power needs, countries should have the capability and consider its use?

Mr. **Odom**. As you know, the development work of reactors is continuing. That is certainly a candidate. It is not one that right now would be in our baseline program. I would not rule it in or out at this point.

Mr. **Torricelli**. Thank you, Mr. Chairman.

Mr. **Odom**. I would like to go back to one point, and that is if you go back to the budget we submitted last year we have not moved our program.

Mr. **Nelson**. I want to get that clarified. I want to read from your statement, in which you said:

"We are still on schedule for all major program milestones, including the first element launch in the first quarter of 1995, mantended capability in the fourth quarter of 1995, permanently manned capability in the fourth quarter of 1996. . . ."

Gentlemen, I need your attention on this because it addressed the 1998 question that Mr. Torricelli just addressed.

". . . permanently manned capability in the fourth quarter of 1996 and assembly complete in the first quarter of 1998. These dates are the same as those presented to you last year."

Mr. **Odom**. That is correct.

Mr. **Nelson**. Last year we were operating under the statement that the first launch was going to be in 1994, not 1995, that in essence the assembly was going to be complete and operational in 1996. What you are saying is you are going to have permanently manned capability in the last of 1996 but you are still going to assemble. Then by 1998——

Mr. **Odom**. I think the earlier dates that you had were the 1987 baseline dates. That with the 1988 cut moved one year.

Mr. **Nelson**. What is that?

Mr. **Odom**. The dates that you were referring to that ended up with the assembly complete in 1996, at that point in time that was the 1987 baseline before the 1988 funding cut. At that point in time, fundamentally, the program moved a year.

In our 1989 submit to you are the same dates that we have today. So that deferral came a year earlier.

Mr. **Nelson**. All right. If by the end of 1996, then, on the schedule you have just laid out you have a fully manned capability, what is it that you assemble and show us on this model between the permanently manned capability in 1996 and the fully operational capability in the first quarter of 1998?

Mr. **Odom**. Let me describe that for you, Mr. Congressman. I think I can do that from right here.

We will bring up the additional power module. We will bring up the JEM. The Japanese module will come up subsequent to the PMC.

Mr. **Nelson**. What additional power module?

Mr. **Odom**. This will be the last of the power modules. In other words, we basically kind of start at one end and build the space station as we go.

Mr. **Nelson**. So you got one of these and you add the other?

Mr. **Odom**. That is correct. We will also be bringing up——

Mr. **Nelson**. The Japanese module.

Mr. **Odom**. The Japanese module and the European module will come up subsequent to that.

Mr. **Nelson**. What else?

Mr. **Odom**. Also, we will bring up some of the logistics carriers and also we will bring up additional of the propulsion systems, basically another tank farm, additional tankage. There will be one on either end.

Mr. **Nelson**. Where are the tanks?

Mr. **Odom**. They are just inside of that first solar array. They will be right in that area. They might not even be on that model.

Mr. **Nelson**. They aren't.

What are the tanks for?

Mr. **Odom**. They are for the propellant used for keeping the space station orbit, maintaining orbit altitude.

Mr. **Nelson**. You will bring up then one whole set of this, but I assume you will have it over here?

Mr. **Odom**. We will already have it. As a matter of fact, that is one of the early things that goes up first, so that you can literally maintain the orbital altitude.

So the thing literally is built quite modularly, as you can imagine, and it is built over the course of 20 flights.

Mr. **Nelson**. You will have your first manned capability in the latter part of 1995?

Mr. **Odom**. That is correct. We actually bring up the laboratory module on the fourth flight.

Mr. **Nelson**. Before I turn to you, Mr. Lewis, let me also follow up on a line of questioning by Mr. Torricelli.

Were we to have some down-time again with the space shuttle, that brings into alternate capability—the Air Force has now stopped building a vehicle on the Advanced Launch System, ALS. They are proceeding with their technology development, and they will make a decision in 1992 whether or not to go ahead with it.

Therefore, does that not renew the question of the cargo shuttle that we should raise?

Give me about three sentences.

Mr. **Odom**. The answer is definitely yes, and we are doing that. The Shuttle C is obviously a candidate for that, and we have looked relative to the space station. We have looked at flights that would be used for that, and we have identified those flights that could be used with the Shuttle C.

Mr. **Nelson**. Then why is there no Shuttle C in this budget request?

Mr. **Odom**. You just got outside of my budget request. We would hope to continue the early study work and would hope to come forward with the Shuttle C start in the near future.

Mr. **Nelson**. Can we plan on that in next year's budget request?

Mr. **Odom**. I certainly hope so, but that is not obviously my call. But it certainly has my support.

Mr. **Nelson**. Mr. Lewis.

Mr. **Lewis**. Thank you, Mr. Chairman.

Mr. Odom, what would it take to get back on the original schedule besides a smile from your counterpart? What would it really take?

Mr. **Odom**. I don't think it would be possible. It would take a lot of money, and I think if we tried to do that, to ramp up at this point, I think it would probably be extremely inefficient and probably not very practical.

Mr. **Lewis**. So you are saying 1998 is the best shot we have right now.

Mr. **Odom**. I think the program we have laid out is already extremely tight and, talking from the funding profile, I think there is adequate reserve in the program, but when I look at the sheer quantities of hardware, I think to bring that schedule back, while it might be possible, I think it would be very difficult and, like I say, probably inefficient.

Mr. **Lewis**. Using a political type of metaphor, how much fire in the belly is there in NASA to get this thing working?

Mr. **Odom**. A tremendous amount. I would say quite adequate.

Mr. **Lewis**. How about the commercial application? Is NASA really interested in the commercial application as well?

Mr. **Odom**. Yes, sir. There are a lot of activities that we have going, not only in individual programs but in our Office of Commercialization, and I think there has been a lot of progress made. I think there is a lot of good work going into that.

The answer is we are supporting that and we believe in it, and I think you will see many of those start to come to fruition in a few years. I think we are early in the commercialization of space as a commercial venture.

Mr. **Lewis**. Following up on the Chairman's question, what if we had a year's hiatus in the Shuttle applications for some particular reason? What is this going to do to the space station schedule?

Mr. **Odom**. Obviously, it would probably end up delaying it at least by that amount. It is something I think the program—I think it is laid out with some degree of resilience in it. I think we could react to it. I don't think—it certainly wouldn't bring it to its knees, but—it is something that obviously we trust won't happen, but it is not an impossibility.

Mr. **Lewis**. Is that going to hurt in the middle of the construction of hardware?

Mr. **Odom**. I don't think so.

Mr. **Lewis**. You don't think so?

Mr. **Odom**. I don't believe it would, no, because I think we would continue with the design and development and the qualifications, the building of the hardware. We would obviously slow it down where it really made sense in the program.

Mr. **Lewis**. Why would that make sense, because you wouldn't be able to meet the targeted schedules?

Mr. **Odom**. I am assuming if that one year was a down-time that that would render the orbiter system or the Shuttle system unavailable, and then I would have to adjust accordingly.

Mr. **Lewis**. So if you had Shuttle C, you could pick any time up?

Mr. **Odom**. We would probably pick up some time, correct. You could certainly protect the schedule. I think you might even pick up some time. It is a little early in the program to say how much you might pick up with the Shuttle C, but it is certainly going in the right direction.

Mr. **Lewis**. Thank you, Mr. Chairman. I have no further questions at this time.

Mr. **Nelson**. I want to recognize our former colleague on this committee, Mike Andrews from Texas, who is joining us today. We are delighted, and of course you can jump in here at any time, but I understand you have got a meeting. So let me just call on you right now.

Mr. **Andrews**. Thank you very much, Mr. Chairman. I am delighted to be back.

You know, I can remember when I served on the committee. The model that sat before the Chairman was the model on the back wall today. They are not the same.

This hearing has disturbed me today in listening to some of your comments and certainly some of the questions. I think one of the problems in trying to justify the station, which we all support, is a need to clearly define what the goals are and what the mission is, and as we additionally see the needs to reduce spending and see these proposed cuts in the NASA budget, it even makes it more imperative, I think, that we have a very clearly defined commercialization strategy that has constancy and that is easily defined, not just by members of Congress but by the American people and American business.

In looking at these items that we talked about briefly today, one of those happens to be at the Johnson Space Center, the Neutral Buoyancy Laboratory, a tank, a $30 million tank of water.

Would you tell me why that is moved off budget and what is the strategy, what part of the strategy does it play to move that item off budget?

Mr. **Odom**. Yes, Congressman.

In looking, as I indicated earlier, many of the things that are not on contract, those were obviously candidates for commercialization. That was one of the facilities that were in the design phase we have not gone out with an RFP for. That will happen in January of next year.

We did find there is some interest on the part of some organizations to participate in that. We went out with indication of interest to industry. There were about 30 people who picked up the packages. We have heard from those now, and there are about six or seven, I believe, that are quite interested, and it looks like it might be viable.

That is where we are right now in that process.

There is underwater work that goes on, as you are probably aware, in the Houston and Galveston area, much akin to what would be done in that tank. So there does look like that there would be joint usage and interest, of mutual interest between industry and ourselves in that facility.

So for that reason we put that one kind of high on the list to really go penetrate and see is it real and see if we can make it happen commercially. If not, we will have to react very quickly and get on and finish the design.

Mr. **Andrews**. That is a good point. Does this put us off the timetable?

Mr. ODOM. No, it does not. If I do not start construction in January of next year, it will put me off the timetable. So I have between now and January to bring this to fruition.

Mr. ANDREWS. Mr. Sensenbrenner said a little earlier that it looked like you used a ouija board to make some of these decisions.

Could you say about the other proposals that they are part of a plan, part of a strategy to encourage commercialization?

I think he is right, and I am afraid that what you have done or what the Administration has done is made these decisions—maybe not the buoyancy tank, but some of these others—based on budgetary concerns and the decisions are being driven by budget decisions and not by space commercialization decisions. There is not this overall space commercialization policy clearly defined as to where we are going, what the reasons are.

Mr. NELSON. I think you have said it to him very well.

Mr. ANDREWS. I am not just making a statement. I am asking you to respond.

Mr. NELSON. It is difficult for him to respond.

Mr. ANDREWS. He cannot take down a smile. So you have to answer the question. [Laughter.]

Mr. ODOM. Let me assure you that we are in the agency, in concert with the Administration, working very diligently to arrive at a commercialization plan, and we have made significant progress in that. We do have criteria even in the space station program that we evaluate proposals against.

I think you are seeing in the interest of trying to commercialize, both on the part of ourselves and the Administration, that we have picked up some that may be very difficult because of the fact that they were not under contract at this point and wanted to run it around to see if they are interested.

Mr. ANDREWS. You see, decisions like this, though, in this budget I think undermine the very credibility of what the committee is trying to do and what you are trying to do to encourage commercialization. That is, I think, the point that some of the members have been trying to make here.

Just tell me very quickly what are the commercial uses of the space station? What do you hope to achieve in the short term?

Mr. ODOM. In terms of the whole space station? I think that is a very difficult question.

Mr. ANDREWS. That is part of the problem. It shouldn't be a difficult question. You are the Director of the space station. That is a very fundamental question here that we are telling business people in Houston and all across this country and men and women that work in NASA, and I think that is something we really need to discuss at length because that is a very fundamental question.

It cannot be a difficult question to answer if we are going to fund this program in this Congress with these difficult budgetary times.

Mr. ODOM. I do think, let me say, that there are elements and even parts of the infrastructure that will make some sense in commercializing.

I think we have to look at them very carefully and very critically and pick those that really make sense, and that is what we are all trying to do.

Mr. ANDREWS. Thank you, Mr. Chairman.

Mr. NELSON. Mr. Andrews, you, as usual, are your insightful self, and I think you have pointed out that what we are doing is we are skewing, we are obfuscating the meaning of space commercialization here when you propose this.

This is not space commercialization. Space commercialization is taking private entrepreneurs and using space as the environment in which to carry on enterprise. Space commercialization is not this which is an attempt to take things off of a budget so that the total number looks less than it really is.

The way this works is that instead of committing the money in the 1990 budget for all of these different items they have in essence a contractor go out and build the thing and the government leases it at a later date with a commitment for that money that comes downstream in later budgets, and that is what is being referred to as commercialization here, and that just doesn't wash.

That is not space commercialization. That is a budgetary sleight of hand with smoke and mirrors, and if it is the only way you can fund this ambitious program, then so be it. Let's get it out on the table and call it what it is.

But I am not sure this committee wants to deal in that way. We want to deal in the real costs of the space station and, as some of the most ardent advocates of space commercialization on Capitol Hill, this committee wants to keep clear what commercialization is.

Commercialization is going to take place in that module right there as you start doing materials processing. Commercialization is going to come as a result of what some of these instruments are going to be recording and then selling those products back on earth.

Commercialization is going to be some of the vehicles that are going to move around, that indeed become a part, an extension of private enterprise, not this kind of budgetary sleight of hand.

Mr. McMillen.

Mr. McMILLEN. Thank you, Mr. Chairman.

I am particularly interested in the development of the polar platform and the management of that platform, particularly your rationale for the advantages and disadvantages of transferring that from the Office of Space Station to the Office of Space Science.

I would like you to elaborate on that. My concern is whether that might in fact exacerbate the whole decentralization of management issue that has been brought up before.

Mr. ODOM. Okay. As I am sure you are aware, the polar platform has an integral part of the space station program since its inception. The complementing of the polar platform and its instruments in polar orbit with corresponding and complementary instruments on the base were part of the Space Station Freedom Program, like I said, from the onset.

Your observation is correct, in that the polar platform is really a smaller part of the EOS program and the instrument program. I think, as was in the decision process at the onset, the desire to strive for commonality and reduce cost between subsystems on the manned base and subsystems on the polar platform, I think there will continue to be an ability to minimize cost and to recognize those commonalities.

Those were fundamentally in the decision process to put it there.

In my judgment, that extraction could be done any time. In my judgment, however, it would not be prudent to do that until we get probably to the completion of the preliminary design of Space Station Freedom, which we will finish up in the July time frame of next year.

At that point in time you will really know how many of the components and boxes really are common. If there is a lot of them, then you may want to leave them. If it is not, we may want to reconsider.

That is something that Dr. Fisk and I literally monitor on a monthly basis and make sure that we will come to the right conclusion at the right time.

Mr. McMillen. So a definitive decision will be made?

Mr. Odom. I would say in the spring or summer of next year, left to my own devices.

Mr. McMillen. The National Academy of Sciences' transition study recommended that the space station be optimized for life sciences. Currently, NASA really has no platforms for life sciences on board the station.

Can the station accommodate more life science experiments, more laboratory modules?

Mr. Odom. Can it accommodate more life sciences?

Right now the space station is being configured to accommodate life sciences as well as the other sciences, and at this point in time we literally have not made an allocation of what part of the elements of the station. That is the beauty of this configuration. You can make that decision as you make the decision relative to what instruments you want to develop and when will they come to fruition.

Let me assure you that the configuration that we have will accommodate much more than the life sciences.

Mr. McMillen. I guess my question I meant to say was, can it accommodate a comparable level of experiments as compared to, say, materials development?

Mr. Odom. Very definitely.

Mr. McMillen. I guess that is all I have. Thank you.

Mr. Nelson. Mr. Schiff.

Mr. Schiff. Thank you, Mr. Chairman.

Briefly, Mr. Odom. First of all, I want to say I came in from my district last night, went to my apartment, turned on the television, and there was a special on the needs of the space program and NASA's problems, particularly as caused by Congress.

I want to congratulate NASA for getting that on the air the night before this committee hearing, and have no idea how they did it.

But seriously, I was also interested in the 1998 target date for the space station. Several of my colleagues have remarked upon it.

What I would like to ask is does NASA seek an earlier time schedule? Is this the time schedule set out by budgetary limitations or scientific limitations, or is it a natural progression of the steps NASA thinks are needed in order to have an operational and safe space station?

In other words, if you could do it faster, would you do it faster?

Mr. **Odom**. I think the answer to that question is we have laid this program out very cautiously, very deliberately, and very thoughtfully. We have looked at really the long term developments, what hardware we really think is going to be the long poles in the tent.

I will say we have put some reserves in the program right now both as to cost, and there is some schedule reserve in the form of costs, but that comes in the last three to four years of the program.

One could possibly bring it back, but I think it would be inefficient, and it is much too early in the program at this point, in my judgment, to make that decision, to make the decision to try to go back. There is very little reserve this year and next year and the following year as compared to the shape of the reserve in the last years.

So I think the program has been laid out, I won't say comfortably, but I think it is fairly tight, and I would not at this point recommend trying to pull it back.

Mr. **Schiff**. In terms of funding, then, the funding NASA will be seeking is the funding along the schedule between now and 1998 as opposed to, at least as known now, a speedy supplemental request to move things further; is that right?

Mr. **Odom**. Absolutely.

Mr. **Schiff**. I realize this would probably take a lengthy answer, but in view of the fact that the Soviet Union has a space station now, though I realize from Dr. Fletcher's testimony before this committee our space station is considered a great deal different, do you believe we need that number of years to follow those steps even on a tight schedule?

Mr. **Odom**. That is correct. We are putting elements in the program to allow us the capability to start using the space station even before we have either manned it completely or manned it permanently or assembly is complete. We have actually put into the program—we have brought the laboratory module up early on the fourth flight. We literally can start using and will start using the laboratory and the space station even with the sixth and seventh flights, which are in early 1996.

So we literally will start using the space station just as soon as is possible. So we are literally not waiting until assembly is complete or even permanently manned to start using it as a laboratory.

Mr. **Schiff**. One last thing, Mr. Odom. In view of the budget situation that you are more than aware of what we face, in view of the many pressing needs of the budget, different individuals have suggested that we really could accomplish with robotics most of that which a manned space station would accomplish without the same cost or anywhere near it.

I assume NASA reviewed that option before pressing ahead and recommending the space station, is that correct, the manned space station?

Mr. **Odom**. That is correct.

Mr. **Schiff**. Thank you, Mr. Chairman.

Mr. **Nelson**. So the committee knows the extent to which we are talking about items off budget, we may as well just get our terminology straight and stop calling this thing commercialization. This is off budget items.

One is the neutral buoyancy tank at JSC. Two is the station payload processing facility.

We have got Fletcher's letter up here. The station processing facility, they are saying total estimated cost of $84 million. The neutral buoyancy, the total estimated cost, $30 million. The observational instruments laboratory, $14 million.

The next one, a fourth one, is the flight telerobotics servicer. How much is that?

Mr. ODOM. That would be $45 million. It is $15 million in the budget, $30 million removed.

Mr. NELSON. That is $45 million.

The station docking mechanism?

Mr. ODOM. That is the STS side, and I don't have that figure.

Mr. NELSON. All right. Is $10 million approximately?

Mr. ODOM. It is less than $30 million. I guess it is in the $20 million range, but it is not designed. So I am not sure yet. But I would say in that category.

Mr. NELSON. The logistics module?

Mr. ODOM. The logistics module will be in the neighborhood of about $80 million.

Mr. NELSON. And the last one of the seven is the extended duration orbiter.

Mr. ODOM. I don't have that.

Mr. NELSON. We will get that later.

All of these are off budget items, and this is a major departure. What ought to be happening is that you all ought to be coming to us with all of these proposals.

Where is this proposal?

You ought to be coming to the authorizing committee.

And there is an eighth item, advanced solid rocket motor facility, that is scheduled to go off budget.

So where is all this stuff? Why hasn't—this has to be proposed legislation. This has to be law in order to allow you to do this. So where is your proposal?

Mr. ODOM. Those are being worked individually. We have a timetable to get back to the Administration as well as the Congress, and obviously each one of them has a different schedule, but we are very actively pursuing that process.

Mr. NELSON. Mr. Mineta, you are next, but let me just say, is this the proposal that is bogged down in OMB?

Mr. ODOM. Some of them are.

Mr. NELSON. What do we do to get it unbogged?

Mr. ODOM. I think that challenge is obviously between ourselves and OMB. We need to finish working those to arrive at criteria and a mechanism by which to deal with each one of them because I think you will find that each one of them are peculiar in and of themselves, and we will have to work them individually.

There is no blanket that I see that you can spread across all of those that deals with all of the aspects of commercializing.

Mr. NELSON. I will get back to you, Mr. Rohrabacher. Let me get to Mr. Mineta.

Mr. ODOM. Mr. Chairman, let me go back to the $80 million. That is in our budget. That is not one that is in our submit to you. So that one is not unbudgeted right now. It is one that is a candidate that we are looking at for commercialization. So that one is in our submit.

Mr. **Nelson**. You know, we can save ourselves $13 billion if we just took the whole thing out and put it all off budget.

Wouldn't that be wonderful? [Laughter.]

Mr. Mineta.

Mr. **Nagle**. If the Chairman would yield on that point just for a second.

Mr. **Nelson**. Yes.

Mr. **Nagle**. I got a report that I wonder if you would be kind enough to comment on. It is a memorandum from the head of the Executive Department Agencies, from Joseph R. Wright, Acting Director of the Office of Management and Budget. I understand this is the second draft.

It is a two-page report, and I could read it to you, but it is quite critical of the lend lease proposal as actually not resulting in any cost savings. Although you may save money up front, you lose a lot of money in the latter years. Your budget exposure goes up to the very time when the space station itself—the outlays are going to increase dramatically.

Are you familiar with that report?

Mr. **Odom**. I don't recognize that report. I am sorry, sir. I do not recognize that report.

Mr. **Nagle**. Why don't I give it to you and you can read it, and we can talk about it when it comes around to me again if that would be okay. [Laughter.]

Mr. **Nelson**. Have you met our bulldog? [Laughter.]

His name is otherwise Mr. Nagle.

Mr. Mineta.

Mr. **Mineta**. And that 800-pound gorilla today has a cold and isn't feeling well, so he is not in a good mood.

Mr. Odom, I want to follow up on a question Mr. McMillen started to ask about because you tried to assure him about life sciences. Frankly, it was no assurance at all.

Let me ask, how important a role does the life science research program play in the whole space station program?

Mr. **Odom**. The life science program, not only in the Freedom program but across the agency, is an extremely important program. We are quite dependent on not only the life sciences in support of our crews, but also there is a lot of life science work and medical work that in my judgment will have a lot of terrestrial applications.

But the facility is being designed to accommodate the quantities of life sciences that compete with all the other sciences, and we have a very extensive——

Mr. **Mineta**. Mr. Odom, you can't BS a BS'er. You have no plan for life sciences. Mr. McMillen said NAS said you have a plan for materials sciences, but you have no plan for life sciences. What you just told me is mere words, baloney.

Mr. **Odom**. We do have plans for life sciences.

Mr. **Mineta**. Is it on the laboratory module?

Mr. **Odom**. It is both in the lab module——

Mr. **Mineta**. Tell me, where is it in the lab module?

Most of your racks are filled with materials research, not life sciences. You don't even have it on the module. You have it on the node.

Mr. **Odom**. Right now the actual rack allocations have not been made. The capability to put life sciences as well as materials sciences as well as other sciences is quite flexible at this point so far as the facility design that I am designing.

As the agency and the science community collectively agrees on what experiments will fly in what year, then I believe the facility will be able to accommodate a very good mix of those.

Mr. **Mineta**. Yet we are talking about a base on the moon. We are talking about a mission to Mars. We are talking about long-term habitation in space, and I just don't see this emphasis or the kind of attention being given to life science that I think is necessary to even do these things.

What is the main experiment for life sciences? The centrifuge?

Mr. **Odom**. That is one of the keys, that is correct.

Mr. **Mineta**. When is that slated for the space station?

Mr. **Odom**. We have not picked the flight that it will go up on. That depends on the capability of the launch system.

I would like to go back to a point you were making earlier. There have been cuts in our life science program in the last couple of years that have deferred some of the life science work. We would hope that we will pick that piece up.

Mr. **Mineta**. It sounds like the cuts came within the last couple of minutes. You were talking glowingly about what life science programs are. Now, you are willing to acknowledge there have been some cuts.

You know, the problem I see—and I look on MB-7, U.S. habitation module, MB-8, -9, -10, -11, -12, and I am wondering where is the centrifuge. Why is it not on the laboratory module? It is on a node. Why? Because you can't accommodate it from a power hookup.

Is that one of the problems with it?

Mr. **Odom**. Would you like to address that?

Mr. **Mineta**. It bothers me.

Yes, sir.

Mr. **Tanner**. Mr. Mineta, if I might.

One of the activities we are currently engaged in is the implementation of the centrifuge in Node No. 4. This centrifuge is located with some two or three racks of equipment and will be, at the successful accomplishment of that, with additional racks of equipment located at the end of the laboratory module, so that in effect the life sciences extends from the laboratory module into Node No. 4.

In addition to that, in the habitability area there are a number of biological aids in the crew health experiments and crew medical center that are considered to be life sciences.

The only delay that I am aware of in the life science area has been the deferral in the establishment of the support equipment that goes in those racks between the lab module and the node. That was in response to the delay in the funding expenditures rate associated with the 15th of May.

But in fact there is a very vigorous life science program associated with the space station.

Mr. MINETA. What about that? Given the reference to the node, what about the power hookup? Is that still configured for a low powered hookup, given that it is a node that cannot be accommodated in the laboratory module?

Mr. ODOM. You mean so far as the centrifuge itself?

Mr. MINETA. Yes.

Mr. ODOM. No, sir, that is not a problem. You can get the same power there as anywhere.

Incidentally, let me just make kind of two points.

One is, as you heard Ray say, that is a double rack size. It literally does not—it may turn out that it doesn't go in the node right now. We think that is probably the logical place, but there is one other point I think we need to make.

The part of the budget that you are addressing relative to the life sciences is not a part of our budget. That is really the Office of Space Science, and Applications' budget. So you really need to get those indications from them.

Mr. MINETA. Aren't you sort of the integrator of the system? You can't shove it off on them if you are the integrator.

Mr. ODOM. We are the designer and provider of the laboratory. The actual racks and experiments, the majority of that comes through the OSSA.

Mr. MINETA. It looks like right now the materials science goes right up after the lab module is deployed. It looks like the material science equipment goes after that.

Do you have a schedule for the life science package deployment?

Mr. ODOM. That outfitting flight you are referring to there can be whatever the science community chooses it to be. That has not yet been decided, all the racks that will fly up on that flight.

Mr. MINETA. I am just disappointed, frankly, in what is happening as far as life science. It is important in terms of our own capabilities of long term space habitation. We don't have the experience with it, and we want to go on to Mars. We want to base something on the moon. It just concerns me that we don't have the kind of knowledge that we should have, frankly.

The other area I was going to get into was Shuttle C, but, Mr. Chairman, given the limitations of time, I won't do that. But again I think Shuttle C is very, very important given what is happening with Energyia, given the number—when I see the kinds of scheduling of our flights and the number to me is just unrealistic. I really think we ought to be doing something more on Shuttle C, which you touched on, Mr. Chairman.

I will yield the balance of my time to my 800-pound gorilla friend here whenever his time comes up.

Mr. NELSON. Mr. Mineta, you are right on, and I think we ought to examine Shuttle C in light, particularly, of what Mr. Odom has said here today and what you have said and what we now know is the deferred program in the Air Force on an advanced system.

So what we are going to do is carve out a hearing on specifically Shuttle C so that we can focus in on the details.

Now, Mr. Odom, my heart really goes out to you today because you are taking the brunt of a great deal of frustration of this committee when you don't deserve to take it. You just happen to be—as Mr. Rohrabacher said, you are the messenger that has delivered a message that we don't like at all and defies description because it is a financing scheme that is not a way we are supposed to appropriate monies of the United States Government.

And so what we are going to do, we are going to schedule a hearing and we are going to have your boss, Dr. Fletcher, in here, and we want him to clearly enunciate the reasons why he is proposing and give us the proposed legislation instead of playing this mating dance that we are going through where you are not giving it to us, and we have been asking for this for the last two and a half weeks.

Indeed, when Dr. Fletcher was here two and a half weeks ago, he was supposed to present it, and we are tired of waiting. We have got to move on with the authorization process, and we would like to have it.

We are going to schedule a hearing, and we would expect you to have that.

Now, let me just for your edification, since you are the messenger, so that you can take this back to Dr. Fletcher and you can also take it back to the Director of the OMB. I have in my hand a memorandum for Heads of Executive Departments and Agencies.

Mr. NAGLE. Hey.

Mr. NELSON. Is this yours?

Mr. NAGLE. That is mine.

Mr. NELSON. This is the lease purchase, okay. Well, I don't want to take away from the bulldog.

Mr. NAGLE. You write your own stuff. [Laughter.]

Mr. NELSON. Let me just leave the goodies then to you, Mr. Nagle.

I will just read the first sentence. The first sentence says:

"A number of agencies and committees of Congress have proposed financing schemes involving lease purchase arrangements that enable agencies to purchase capital assets without having to score the full cost of the purchase in the current budget year."

It makes reference to an OMB circular that requires agencies to conduct lease purchase via analysis.

Obviously, you all haven't done that lease purchase via analysis. When Dr. Fletcher is here, we want you to have it.

Now, I promised Mr. Rohrabacher. He had a comment. And then we will go on to Mr. Smith of New Hampshire.

Mr. ROHRABACHER. First, I am new at this. It is my freshman term. I want to commend the Chairman because I am a man of words. I am a former journalist, and he pointed out some nonsensical uses of the language today that I think was very important to us.

You know, this word "commercialization." To misuse that word, as has been done here, is doing a great disservice to this committee and those of us who are trying to make a plan for the future.

I happen to believe, as do the rest of the members of this committee, that commercialization of space is just vital to our future. The fact is I think we could have commercialization in space. By the end of this century I would hope to be paying more money to those of us, more returns to those of us on earth than we are putting into the space efforts itself. I would hope maybe if not by the turn of the century, within two decades of it anyway.

So I would like to commend the Chairman, first of all, for his astute analysis of the language and putting a little bit of sense back into the words we are using here.

But what we are really talking about is not commercialization. We are talking about using private sector money to accomplish our goals; for example, that gigantic swimming pool you are proposing to build in Texas. There might be some merit to using private sector money in all of this because then you might be able to put it to other use after we are done with it, but that is not commercialization. It is not what anybody had in mind for commercialization.

My earlier question, you mentioned that the Japanese and other foreign investors were putting $8 billion into this project. Well, there is $8 billion that will be coming to us, and we have got other private sector money, possibly in the swimming pool and other places.

Are there other things that you might be able to attract the private sector money into furthering the goal here of putting the space station up?

Mr. **Odom**. I think, Mr. Congressman, it is probably early for me to give you examples. Like I said earlier, I think there are some areas in the infrastructure that may be possible, but I don't think we are far enough along in this program to really commit to real commercialization in the terminology that you are referring to. I would not want to say they are not there.

Mr. **Rohrabacher**. One note of optimism. I always like to leave things on a note of optimism.

The fact is that although we haven't seen a lot of examples of this work just yet, if you take a look—in terms of commercialization, if you take a look at the space station itself, all of us have to keep in mind that this is designed so that we can meet unseen potential in the future for commercialization. This is designed so we can add on different elements to take advantage of the opportunities that new technology is going to give America. That is what the space station was designed for.

I think we can all be happy with the fact that we may not see some of the things this thing is going to be used for right now. In fact, many of the greatest achievements that we have had scientifically in this century were unseen by people who were 20 years earlier. They had no idea that that potential was going to arise.

We have designed the space station, and you can just take a look at it. I can add the different things to it and add new methods of getting energy in here, but we have designed this to meet the unseen potential that we know is out there in the future. It is a statement of faith in the future, and so although we are giving you a little hell here today about some of these things, we do recognize there is potential there and the space station is designed to meet the potential, although there are serious questions that need to be answered.

So thank you.

Mr. **Nelson**. Mr. Perkins was next, and then Mr. Smith.

Mr. **Perkins**. Thank you, Mr. Chairman.

I apologize for missing a good deal of the testimony today. I have read it, and unfortunately sometimes you do have other commitments. I have a lot of questions. I am going to try to be brief actually.

I had a good conversation with Tom Moser about a lot of this, I suppose, last week. So I am going to leave some of the bulldog questions to Mr. Nagle, who seems to enjoy those things, and I am going to ask specifically about an interest that I have very strong feelings towards, and that is the use of the space station as a part of the infrastructure which we hope to eventually continue outward to the moon, to Mars, colonization, whatever.

At this juncture, what specific plans or integration type analysis has NASA taken so that the space station will become an integral part of this process?

Mr. ODOM. Even the early studies indicated to us the kind of size, the kind of real estate, the kind of property and facilities you would need in space if you wanted to assemble larger vehicles and go to the moon or go to Mars. That capability to accommodate that was in the original plan of the space station.

Because of budget reductions that capability was taken off, but let me assure you that we are designing the space station with what we refer to as the hardware scars, where we literally can take that configuration and literally add the capability right onto it and build it up out of the Shuttle or with the crews just like we assembled this one.

So even though we do not have in our basic program now the capability or the inclusion of the hardware for that accommodation, we do design it so that it can accommodate that growth.

So we believe and work very closely with our Exploration Office as we understand the configurations of those vehicles and what they may look at, what the propellant systems are, what the assembly sequences may be. Then we can adjust to accommodate that.

But let me assure you that is very high on our list of accommodations to make sure that we keep that capability.

Mr. PERKINS. Mr. Odom, I certainly agree that it is good to have it high on your list, but from your answer it strikes me that presently we have nothing in terms of hardware, as you indicated.

Secondly, we are working with the Exploration Office to try and get some sort of idea as the configuration begins to take shape.

That strikes me that really we don't have any idea at all how we are going to use this in terms of going outward at this juncture. Is that right?

Mr. ODOM. That vehicle has not been defined, that is correct.

Mr. PERKINS. At this stage it is an area that I would urge NASA to take further strides in and looking at. It strikes me that one of the problems we have had in the space program for a long period of time has been not building upon or having a longer term type goal, so that as we work our way out we don't just have a stop and start type process where we suddenly build something that is a goal in itself with nothing else coming afterward in terms of logical development. Then you have to start up again for another short term type of goal.

I would urge some type of process whereby we have a little bit more far-reaching type of orientation. I realize that with the budget constraints that is a difficult thing to do, and I realize that changing of the internal—well, who is in NASA, who is in Congress. Things change. I understand that. But it strikes me that we are looking rather short term and narrowly, certainly in terms of this proposal.

In conjunction with that, I suppose—and I think you indicated earlier in your testimony that certainly you thought that the power situation was adequate, but you were going to be tight—Tom Moser indicated the same to me last week, that he felt comfortable with the ability to add on power as was needed, I suppose.

You are going to be using what, 75 kilowatts initially? What type of expansion presently is viewed toward the—oh, let's say if we should institute Phase II—towards the total power needs that would be needed of the station at that juncture?

Mr. ODOM. To go to the kind of assembly we are talking about, you are talking in excess of 150, maybe 200 kilowatts.

Mr. PERKINS. I would think at least 200.

Mr. ODOM. I would think 200, even higher. It would depend on the state of the vehicle.

Mr. PERKINS. In terms—is it the photovoltaic that you are interested in using for expansion there?

Mr. ODOM. Right now I think we would not go with the photovoltaic, but more than likely go to a solar dynamic system for that growth. That development work is continuing, and right now that would be the most logical candidate.

Mr. PERKINS. I will leave it with that today. I am not going to go overboard.

Mr. ODOM. I would like to go back to your first comment.

The agency does have strategic planning going on to address what you are talking about, and we will in the next few months be a bit more specific relative to what we think those long term objectives should be, from an agency standpoint.

Mr. PERKINS. I have been asking for that since I have been on this committee, and it is something that is difficult to pin down. We read the reports, but we still haven't gotten anything really, in my opinion, from NASA on that.

I am not trying to pin you down because you are concerned specifically, I suppose, with the space station, but in terms of the space station and its place in the larger concept I still get the feeling that it is just a short term type project. With the longer term it is not being integrated in.

I think it is probably logical to assume—and certainly I accept the fact—that it is a vital link in the infrastructure for the need for further development to go out. I guess the problem is why didn't we go to the moon and stay on the moon initially. Why didn't we have something in place where we were able to go and maintain some sort of presence?

I think certainly the space station puts us in that direction, but I think again it is going to be something—if we are not prepared to move after we have assembly, that it is going to be another start and stop type situation.

So I would urge at this relatively early date that some preparations be made in that regard.

With that, I will yield back to the Chairman.

Mr. NELSON. Thank you, Mr. Perkins.

Mr. Smith.

Mr. SMITH of New Hampshire. Thank you, Mr. Chairman. I know Mr. Nagle is very anxious to get in here, so I won't take much time. I will be happy to yield any I have left to my colleague.

I just want, lest there be any doubt about bipartisanship on this issue, I certainly would like to lend my support and associate myself with the comments made by the Chairman and Mr. Andrews and others regarding concern about this so-called commercialization aspect in the budget.

We all support the commercialization of space, but again—I am probably repeating what others have said—it seems to me that this whole thing is budget driven. Many things have to be budget driven in this place, unfortunately, but I don't think this one should be, nor does it have to be.

I think you have an unlimited amount of interest, ability, capability, whatever you want to call it, to get involved and make this not only the space station but in other aspects of NASA's budget as well, and I don't see—at least in the testimony I have heard here and the questions I have heard and the responses to the questions, it just seems to me like we are moving along piecemeal, saying, well, if we get the commercial provider, then we will do it. If we get another commercial provider or something else, we will do that without a real long term objective laid out specifically so that these commercial providers would know exactly where they fit into the picture.

I guess just one or two quick questions.

What happens if a provider can't provide? What contingency plans do you have if that happens in one of these projects in a critical part of the space station? Is OMB going to drop the money in? Where are we? What happens then?

Mr. ODOM. I don't think we are far enough along for me to answer that, Congressman Smith. As I said, we are just not far enough along in the process to have worked out either the facts with the contingencies yet.

Mr. SMITH of New Hampshire. I know, Mr. Chairman, your comments about the messenger, and I understand that, Mr. Odom. So I am not going to give you a hard time personally, but I for one—just speaking for myself as a member, I don't see how you can ask us to make a decision on a budget like this, especially on something as important as a space station. There is not a member of this committee that doesn't support it and doesn't want to see it happen.

How can you ask us to make an intelligent budgetary decision without an answer to that question?

I certainly can't do it. I don't think anybody else can.

Are you applying the same criteria to other aspects of the NASA budget as we are applying here to the space station in terms of commercial providers being questionable? Well, yes, if we can get them; if not, we scrap the project? Is that being applied to other standards of the NASA budget, the other—how much—8, 10, $12 billion? Is that being applied there as well, the same criteria?

Mr. ODOM. Only, to my knowledge, in ASRM, but I won't be the one to address that.

Mr. SMITH of New Hampshire. You can't tell me if we are using the same commercial link contingencies with the other aspects of the NASA budget as we are with the space station?

Mr. ODOM. I don't think to the degree, certainly. That is another part of the budget. That is a candidate for commercialization. So there are some others, but I think the percentage is probably much smaller.

Mr. SMITH of New Hampshire. One final point. What about the staggering of funds?

This may have been asked, since I came in late? Was it asked?

Well, I will drop it and yield to my colleague whatever time I have got left.

Mr. NELSON. Mr. Nagle.

Mr. NAGLE. Do you want to take a second and review that OMB report that you have in front of you?

Mr. ODOM. Yes, I have glanced at it.

Mr. NAGLE. I am sorry. Every time I sit next to Mr. Mineta, I get caught in the Second World War. So I talk about lend lease instead of lease purchases.

But I was kind of curious about the letter that Dr. Fletcher sent us.

He says in the letter to us—the stamp date received is February 22nd, 1989—he says—and I quote—on page 2:

"If financed privately, the total cost of each facility," referring to these lease purchase agreements, "would be completely or substantially amortized over an extended time through payment to the proposers."

My question is, in light of what OMB has said about its position about lease purchase agreements, it seems to me there has been a conflict there between his optimism and OMB's skepticism.

Can you reconcile that for us?

Mr. ODOM. I have not seen this letter. Obviously, the lease purchase is one of the options. We would obviously have to go back in each case and work that.

If the intent of this letter is to discourage lease purchase, then obviously some of the approaches that we might have looked at in the past may not be that attractive. So we would have to deal with that.

Mr. NAGLE. They are rather graphic about it. This letter was written October 19, 1988 by James R. Wright, the Acting Director. He said, and I quote, in the fourth paragraph.

> Lease purchase arrangements are more costly to the federal government than the outright purchase or construction of an asset, since agencies must pay the costs of the borrowing, which is more expensive than the cost of Treasury borrowing. These also create secondary markets for federal government borrowing, which competes with Treasury borrowing and drives up the cost.
>
> In addition,

he says,

> They encourage pork barrel spending and pious decisionmaking.

It would appear to me that unless there has been a change in the Administration's policy they are not really encouraging you to come to us with a lease purchase agreement.

Has there been a change in their philosophy over there that we haven't been told about?

Mr. **Odom**. I don't know, sir.

Mr. **Nagle**. Okay. So then are you familiar at all with the CBO study, the Congressional Budget Office staff memorandum, "Preliminary Analysis of NASA's Commercial Initiatives"? Have you had a chance to review that?

Mr. **Odom**. I believe I have seen that.

Go ahead. I think I have seen that, yes.

Mr. **Nagle**. I am quoting from the third paragraph on the first page.

> The weakness of potential non-U.S. Government demand for facilities proposed for commercialization would leave NASA without private offers to accept the risk of even a low level shared use and cost. If commercial interests were permitted to go forward, even though they would likely be more expensive than direct procurement, it would be reasonable for Congress to expect some additional benefit to the nation in return for the additional costs incurred through private financing.

Again, the CBO seems to be saying it drives the cost of the project up even higher.

Mr. **Odom**. It could very well.

Mr. **Nagle**. Further, it says, "The recent history of space commercialization does not give cause for optimism that customers other than the U.S. Government will share the cost of use of the facilities. Specifically, there is not likely to be any demand from sources outside the U.S. Government for three of the seven proposed projects—the space station, the flight telerobotic servicer, the advanced solid rocket motor plant, and the observational instruments laboratory."

You would respond to that how?

Mr. **Odom**. I would think that other than government of those three would probably be unlikely.

Mr. **Nagle**. So if we are going to fairly evaluate the budget for the station, I share the comments of my colleagues. When we come to calculating budget outlays that this committee is going to be engaged in of the seven proposed for commercialization, we should immediately wipe out which four?

Mr. **Odom**. I am not sure which four that would be yet. I really couldn't say that because we are not far enough along in that process to determine that.

Mr. **Nagle**. Isn't the effect of the lease purchase agreement—wouldn't you agree with me that the effect of a lease purchase agreement is to hold down the outlays in the initial years and then they will rise dramatically in the middle years?

Mr. **Odom**. That is a tendency of lease purchase, that is true.

Mr. **Nagle**. So at a time when we are incurring the greatest cost we would also be incurring the greatest cost on these purchase agreements?

Mr. **Odom**. That could be.

Mr. **Nagle**. I was curious to note that your statement to us today says that $15 million—from page 6—

> $15 million will be spent on the flight telerobotic servicer, the FTS. Consistent with Administration policy, NASA is exploring private investment in development of the actual flight hardware. So the funds we request at this time are only for activities that support development.

I guess I am curious about your use of the term "consistent with Administration policy" in light of the OMB memo I just read you from October. It is not consistent with Administration policy, at least as it has been defined to the Congress, to pursue the course that you are recommending that we pursue on these purchases.

Mr. ODOM. Not apparently, according to that document.

Mr. NAGLE. Then why did you tell us this?

Mr. ODOM. I guess that one was written in October of last year.

Mr. NAGLE. This was written in October of last year?

Mr. ODOM. The other policy you referred to.

Mr. NAGLE. That predated what you told us today.

Mr. ODOM. That is correct.

Mr. NAGLE. Why did you tell us this? It is not consistent with Administration policy.

Mr. ODOM. Maybe the policy has changed.

Mr. NAGLE. You know, you can answer any way you want. As a matter of fact, you don't have to answer. But I am not finding your answers particularly helpful nor the inquiry particularly humorous.

Let me go further in your statement.

"The program development cost ceiling of $13 billion" at the bottom of page 6. Do you want to look at that paragraph with me?

Mr. ODOM. Yes, sir, I have it.

Mr. NAGLE.

> In addition to the funding I have just discussed, the Administration proposed legislation for a three-year advanced authorization and appropriation of $8.5 billion covering FY '90, '91, and '92. A program development cost ceiling of $13 billion in 1984 dollars is also proposed.

Okay. Does that assume lease purchase agreements with the savings that NASA has represented to us in the budget submission?

Mr. ODOM. I think the answer to that is, yes, to the best of my knowledge.

Mr. NAGLE. So given the analysis of CBO you can't respond to and your unawareness of Administration policy, we can assume that if they are correct the ceiling of $13 billion in 1984 dollars is probably a very low ball figure?

Mr. ODOM. The $13 billion does not include—we have tried to—for any of it that would show up in the '90, '91, and '92 we have tried to account for it, but that is purely an estimate on our part at this point.

Mr. NAGLE. But it does assume in those figures the lease purchase arrangements?

Mr. ODOM. For the FTS, for the flight telerobotic servicer.

That is the only one that we have addressed in those three years of the budget, and it would assume some kind of payment back.

Whether or not it is a lease purchase, we are not far enough along to define.

Mr. NAGLE. We also know that is one of the ones that has been identified as being unlikely to attract commercial interest.

Mr. **Odom**. That is probably true.

Mr. **Nagle**. So when we say $13 billion in 1984 dollars, my first question is what is $13 billion in 1984 dollars in 1989, 1990 dollars?

Mr. **Odom**. In '88 dollars—it is $15.3 in '88 dollars.

Mr. **Nagle**. And in '94 dollars?

Mr. **Odom**. I haven't run that number. We can supply that to you, sir.

[The information follows:]

The proposed cap for Space Station Freedom development costs is $13 billion in 1984 dollars. This equates to approximately $15.3 billion in 1988 dollars, $16.1 billion in 1989 dollars, and $16.9 billion in 1990 dollars.

The estimates of future year dollar amounts are highly sensitive to inflation and annual funding, so they change if actual inflation deviates from the projections used for these estimates and if annual funding changes.

Items not included in the development cap are:

Space Station Definition.
Flight Telerobotic Servicer.
Transition Definition.
Operations costs.
Orbital debris radar.
Construction of Facilities.
Transportation costs.
TDRS support costs.
Civil service manpower.
Assured Crew Return Capability.

Mr. **Nagle**. And if we take out the commercial initiatives and the cost savings that NASA has told us that they could obtain on the three or four projects in which there is not likely to be a commercial interest, what does the figure go to in 1989 dollars?

Mr. **Odom**. Those dollars are not included, sir. I have a problem addressing that question.

Mr. **Nagle**. Do you disagree with the CBO analysis? Does NASA disagree with the CBO analysis?

Mr. **Odom**. Relative to the additional cost portion of that analysis?

Mr. **Nagle**. Yes.

Mr. **Odom**. What I have seen so far, I would not disagree with that.

Mr. **Nagle**. Do you disagree with the analysis of the OMB that these purchases would increase costs rather than save costs?

Mr. **Odom**. I think without some other kind of revenue stream it would be very difficult to do a lease purchase that would not be an additional cost.

Mr. **Nagle**. Then you cannot at this point tell us how much those additional costs will be?

Mr. **Odom**. I cannot.

Mr. **Nagle**. Is anybody doing any studies on that?

Mr. **Odom**. For each one of them, as we pursue the notion of commercialization on each one, then we will literally run the A-104 analysis that is referred to. That would be a part of the decision process.

Mr. **Nagle**. Would it be fair for me to conclude then that you have submitted a budget to us, in portion, that is contrary to existing Administration policy as we know it, that does not disclose probable costs, the true costs, which would be higher, because it is yet to be determined and it is couched in language of $13 billion when in fact we know today that it is at least 15—whatever you said—and that is the budget proposal today on the space station from NASA?

Mr. ODOM. The budget we have submitted is, to the best of our knowledge, covering the program.

We did indicate that there are a number of commercial items that are being pursued that could affect not only the '90 costs but could affect the run-out cost, and those could not be adequately addressed at this point.

Mr. NAGLE. What can you tell me to allay the uneasiness that I have about your budget in light of the Administration's policy and the CBO studies, both of which preexisted your presentation today? Why should we just go ahead and sign the check for you, in essence, and approve the authorization?

Mr. ODOM. All I can say to you, Congressman, is that we will have to get back with the Administration and yourself and the Congress with the recommendations for each of these and what the real costs and near term, either deferrals or reductions and/or the outyear costs. We owe that to you.

Mr. NAGLE. In other words, the bottom line is today in light of conflicts within the Administration and CBO studies to the contrary, et cetera, the budget submission to us today is incomplete and we shouldn't proceed until we have those figures from you?

Would that be correct?

Mr. ODOM. I wouldn't go quite so far. I think the '90 budget is—certainly there are items on there we have to deal with. The runouts, I think we owe you some additional data.

Mr. NAGLE. That is all the questions I have, Mr. Chairman.

Thank you, Mr. Odom.

Mr. NELSON. Mrs. Morella.

Mrs. MORELLA. Thank you, Mr. Chairman.

I am not sure whether you addressed this earlier, Mr. Odom, but I am curious about why you were having difficulty with personnel.

Is it salary? Is it lack of recruitment?

And, to go further, what improvements have you made in the hiring so that we can move ahead, and does the fact that you are having difficulty or have had difficulty impair the movement?

Mr. ODOM. Let me take them in that order.

The initial problem last year was we did not have the spaces or the authorization with which to hire additional people necessary for the program. This is true in other elements of the agency, but the space station is one of the dominant things right now.

We did get the additional spaces approved by OMB last year. The problem now is, fundamentally, we do not have the resources this year with which to go hire these people. We are working with the Congress now, and hopefully we will clear that up within the next few months.

So far as the recruiting, given that capability, the recruiting has been such that I do believe that we can bring the people and the skills that we need to bear. It is easier to recruit new people on space stations, significantly easier than it was a year ago. I think it is because the program is becoming more viable in the eyes of the people.

So I think the recruitment, while it has been difficult in the centers, it is not that difficult. It still will continue to be a bit difficult for us to recruit people in the Reston, Virginia area just because of the cost of living there.

However, I have seen even additional progress there in the ability. We received an additional 50 spaces last year, to give you an example. We have recruited and literally have already hired 26 of those people, and we were able to bring people in in the mid-range where we really need to be. So I am a bit more encouraged now than I would have been six months ago relative to your question.

Fundamentally, given the financial resources, I believe we can bring the people that we need on this year and also next year.

Mrs. MORELLA. You did not have the authorization and appropriation which you needed, which is too bad. Did it hold you back?

Mr. ODOM. Yes, it held back the hiring. We have had to work around that last year. This year, I think we have worked around that about as gracefully as we could. We are not doing everything we need to be doing right now. That is why you see us pushing very hard to get that additional authority so that we can get our staff complete and functioning properly.

Mrs. MORELLA. Do you have trouble recruiting top-notch scientists because of the salary cap?

Mr. ODOM. Yes, we will. That will continue to be a problem for us. Right now our workforce is such that in the agency we have a preponderance of young people, the 20-to-30-year range. We have a big gap in the 25-to-40-year range. That is the one that is really worrisome to us.

I believe we can bring in the experienced people, but within two or three years I think it is going to be a very acute problem for us, not only on the space station but in the agency.

Mrs. MORELLA. You may want to give some of those comments to us. At least I am very interested in that, in terms of you are then having to train them and having them leave, in terms of what that is going to cost.

Mr. ODOM. Exactly.

[The information follows:]

The need for experienced and skilled professionals in the Space Station Freedom program is now greater than ever. The program is maturing, and we are preparing for the preliminary design review (PDR) which will begin in the summer of 1990. We need additional skilled civil servants at the Program Office in Reston and at the various NASA centers to provide adequate direction and oversight for the work package prime contractors and to perform effective systems engineering. One particular challenge has been to recruit more 25-40 year olds to provide balance with more senior system engineers.

Several factors contribute to difficulties in hiring the necessary personnel. First, the lack of hiring authority has already caused the program to lose numerous qualified applicants. Applicants may experience delays of 6-12 months after hiring before coming on board due to insufficient R&PM budget authority. NASA has requested authority to transfer some FY 1989 funds from the research and development account to the research and program management account and has requested funding for FY 1990 that will allow the program to hire in a more systematic manner, reducing delays and thereby retaining more qualified personnel.

Second, the salaries offered by the government are not competitive with those offered by industry. The Space Station Freedom Program has in many cases taken special measures to hire the necessary personnel. For example, the Program Office has had to process starting salary adjustments for 10 applicants in order to compete with industry. In addition, the Program Office currently has 14 excepted positions, and expects to have an additional 8 to 10. These positions provide salary adjustments of 10-24% for a period of 1-3 years and are used to recruit individuals with unique skills.

Last, proximity to high tech businesses is a problem for the Program Office and several NASA centers. For example, the Reston Program Office's most urgent staffing requirement is for systems engineering and integration personnel (approximately 47% of the total staff). NASA must compete for these professionals against other high tech businesses in the area, and is often unsuccessful for the reasons mentioned above.

Historically, NASA has not had serious problems retaining qualified individuals. However, as government salaries continue to become less competitive with private industry, the agency will not only be less successful in hiring scientists and engineers in the middle and upper ranges of experience, but may also lose more of them.

Mrs. **Morella**. Thank you, Mr. Chairman.

Mr. **Nelson**. Thank you.

Mr. **Stallings**. Thank you, Mr. Chairman.

Mr. Odom, let me make this very brief.

A recent special report from the National Academy of Sciences and the National Academy of Engineering, entitled "Toward an America in Space," states that while the space station is essential to establish the feasibility of human exploration, in its final configuration, hasty deployment and funding levels should not be established without prior decisions on American goals in space.

How do you feel about that statement?

Mr. **Odom**. I think those goals have been defined. I think we have worked throughout the agency with our office of space science and applications, with the science community. I think we believe we know what the science community would like to use the station for.

Mr. **Stallings**. So, it is your opinion that the space station program is consistent with our goals that the folks have worked out?

Mr. **Odom**. Yes, sir.

Mr. **Stallings**. How would the Space Station Freedom be used to support the goal of supporting a lunar base or launching an expedition to the planet Mars?

Mr. **Odom**. What it will provide is not only the capability of extending man's habitability in space from the life sciences standpoint, but more importantly it will provide the capability to assemble the large vehicles that would be necessary to carry the people and equipment to the lunar surface or to the other near planets.

So, we believe the space station configuration that we have will grow to accommodate those servicing as well as assembly capabilities for those vehicles.

Mr. **Stallings**. We have some people who feel that we are doing two or three different things that are generally unrelated to space that perhaps the country can't afford, going in different directions.

If, as you say, they are related and they do enhance one another, perhaps we are doing the right thing.

Mr. **Odom**. We think so.

Mr. **Stallings**. Let me just follow up then. This same report established two major categories for America's space programs. The first is called the core program to include launch vehicles, space science, advanced technology.

The second is referred to as special initiatives. The second category is said to include the space station and other potential future programs such as the mission to Mars.

Do you believe the Space Station Freedom program should be viewed as a special initiative or a more integral part of NASA's core space programs?

Mr. **Odom**. At the onset of a new program, I think the new program has to kind of carry its own weight in the selection process.

If you go back to the report, it suggests that you should have a core program. That notion I would tend to subscribe to, and then as major programs, they should set or carry their own priorities and judgments accordingly.

Once a program like a space station happens or a Hubble telescope happens, that is a long-term program, and that should be included, in my judgment, in the base structure. And then the next new programs after that are evaluated on their own merits.

But I do think that the notion of a base program has some merit to it, and then considering new programs on top of that.

Mr. STALLINGS. Thank you.

Thank you, Mr. Chairman.

Mr. NELSON. Dr. Banks, if you will join the panel here, please.

Dr. Banks is a professor in the department of electrical engineering at Stanford. As I said earlier, he has recently coauthored with Sally Ride an article published in the February '89 Scientific American on Soviets in space.

All right, Dr. Banks, basically give us a comparison, this to the Soviet space station and what do you expect the Soviet space station in 1998 to look like?

STATEMENT OF DR. PETER M. BANKS, SPACE TELECOMMUNICATIONS AND RADIO SCIENCE LABORATORY, DEPARTMENT OF ELECTRICAL ENGINEERING, STANFORD UNIVERSITY

Dr. BANKS. In just a moment I can give you some diagrams of what we think the Soviets think it will look like.

Certainly, the U.S. space station we see here is larger than the space station that we see, the Mir station which is the Soviet space station that has been put in orbit. This station is more similar, I would think, to the second-generation stations which the Soviets are planning, but they have not been so kind as to give us the diagrams.

But I do have some guesses that we have seen in the Soviet press.

Mr. NELSON. While we are waiting on that, why don't you talk to us. They are doing eight to twelve rocket launches a year to support their Mir space station. What are the lessons that they have learned from this kind of logistical support that we should understand as we get ready for this?

Dr. BANKS. Within the context of their overall program, you recall that they are launching about 100 major rockets per year, and the first lesson is that that program is basically taking about 10 to 15 percent of their total space resource to support this. So, there is quite a bit of difference between our program and theirs in that regard.

The program that they are embarked on now typically involves two to three people on orbit permanently now. They have stated that that is their goal. About half the flights are related to cargo.

They have separated the transport of humans from the transport of cargo, and I think that is the primary lesson that we should pay careful attention to.

We all know what has happened in the Challenger disaster. We can see. I heard a question earlier today from one of your colleagues, what happens if the space shuttle should go out of commission.

The Soviets, either by hook or by crook have discovered that by using the Progress tankers and the Proton cargo ships, that they can separate the requirements of getting humans into orbit from the problems related to cargo.

That is very important as we look beyond the initial stages of our own space station, I would certainly hope we could incorporate that type of system in our own programs.

Mr. NELSON. Would that in your mind be something other than the Shuttle C, or would it be the Shuttle C?

Dr. BANKS. If you recall, several years ago I did propose Shuttle C in this committee as an alternative way of getting past some of the difficulties.

However, I think what we are looking at is the difficulty with the Shuttle C is you are putting too much payload into orbit at one time, and it's inevitable that you will lose cargo from time to time.

I think the Soviets, with their Proton booster, their 20 tons per launch, have probably hit on a fairly magical number. You don't want to lose every payload, but 20 tons is much better than losing 100 tons at a time.

Mr. NELSON. Anything like a Progress vehicle, we simply don't have.

Dr. BANKS. We don't have a Progress vehicle. We have skipped past that. We went directly to a shuttle.

Perhaps I could illustrate. Could you go through to one of the advanced slides? Let's look at slide number six.

[Slide.]

We missed that opportunity. I don't think we should cry over spilled milk. But there are ideas for the future. For example, with respect to transporting humans into space, we know the French Hermes vehicles and the Japanese have a space vehicle.

We know the Soviets probably will in the next few years have their own space plane which can take 4 to 6 people into low Earth orbit. And that is launched with an expendable launch vehicle.

There is a lot of value going to low-cost transportation like that if the purpose is simply to get people in space, and I think we have to ask ourselves in the future just exactly what it is we are trying to do with the program.

I believe that is in my written materials, which I hope you would include in the record of these hearings.

Mr. NELSON. They will be included.

Dr. BANKS. Thank you.

You will discover that I had not been critical, not uncomplimentary, but just the national aerospace plane is just in a different direction than the direction we need to transport people reliably into space.

Could you go on to the next one?

I'm sorry, this is the Mir station is the next one.

[Slide.]

The Mir station, as it exists now, what we are talking about in term of the tanker on the right-hand side, you can see—I'm sorry, that's not a tanker, that's a Soyuz, which can carry three people to low Earth orbit.

At the far left-hand side, one of the automatic tankers.

I think one of the surprises Sally Ride and I had when we were preparing this article was to discover that they had been flying the unmanned cargo vehicles to their space station since 1978. And they have been automatic docking, rendezvous, transfer of their propellants into the space stations and have gained a measure of experience that we lack.

As time has gone on, we are discovering that they have done more and more things. The cloak of secrecy has covered their activities.

Let me go on to the next slide to give you a feeling for what their shuttle is in relationship to what the Mir station is. You are asking about sizes.

[Slide.]

There is their DC-9 now, and the Soviet Mir complex approximately 30 meters long or as the length with our truss structure is approximately 100 meters.

If we could go on to the next one.

[Slide.]

To give you a feeling of what is coming along fairly quickly in the Soviet program, we know now that the additional modules, one connecting downward to the Soviet orbiter and a larger module going vertically, are the next in line with respect to additions to the Mir space station.

Each of those is about a 20-ton addition, so that is 40 tons of scientific instrumentation and crew capability that would be added to the basic station.

People have seen those particular vehicles. They are, incidentally, free-flying space stations in their own right. The Soyuz could link up with them, and they could put them into polar orbit and sustain them for a week or so in low Earth orbit independently of the space station.

But this isn't the end of the Mir station. If we could go to next one.

[Slide.]

We are seeing from Soviet sources now things that we believe the docking adapter, which is the very clever addition to the Mir station that distinguishes it from the Salyut from its four large modules you see forming across there at the far end of the vehicle. Each of those could be as large as 20 tons, launched, of course, with the Proton vehicle.

In addition, the accommodations documentation that we do get from the Soviets describing how to use their facility, indicates that a fifth large module like that could possibly be added to the far end.

That brings the Mir station up to a total at mass of probably 130 tons. This, of course, in some sense is a first-generation space station. But even at that point it could house probably no more than six persons on a temporary basis, three permanently and three visitors.

The power configuration involved there would be about 37 kilowatts peak power, but not necessarily average power because there is quite a bit of shadowing by the Earth of the solar panels.

When you leave the Mir documentation, you discover that they have been very modular. These modules are developed in different factories and then put out by different design bureaus.

It is basically only in in-orbit construction that they could ever put this together. They don't have our depth of analysis, and sometimes they make mistakes. It is known on the Salyuts that there were bending moments and they couldn't exercise because it would put the whole space station into vibration.

If we could skip that one and go on to the next viewgraph.

[Slide.]

This is the model then that people like Nicholas Johnson and other people who watch very closely the Soviet space program are seeing appearing on Soviet television and in Soviet periodicals.

The core to it is a large, 100-ton tank, very similar to what we saw in the Skylab area with smaller modules that we can identify with existing Kosmos and Kvant-type architectures that have been put on various parts of the vehicle.

The solar panels are probably photovoltaic. It looks very much like our own space station. However, they are halfway there. You know as well as I do that they have nuclear reactors on orbit now. And they have talked very freely of a 200-kilowatt reactor. I wouldn't be at all surprised to see a station like this, which is the equivalent of our own in the 1995–1998 era as having a nuclear power reactor.

Mr. **Nelson**. Is that equivalent in size to this?

Dr. **Banks**. Yes.

Mr. **Nelson**. And their capability on orbit operationally is what?

Dr. **Banks**. The guess as to when you would begin to see something like this is 1993 to 1994. The Mir station will suffice probably for another three to four years. It will go up to the 130-ton level. The question then is whether they will continue to duplicate Mir. They have talked very extensively about materials processing in space.

The only textbooks in that area of microgravity research and materials processing does come from the Soviet Union. It may be that one alternative path would be for them to replicate Mir and use that as a manufacturing site.

Another would be to go to this type of facility with their very incremental funding and their long-term goals, we just don't know.

Part of the blanket is off. You have seen personally and heard of many of the facilities they have. We just aren't sure, and they aren't sure, I think, until they have thought these things through and go forward to the next step.

At this point, I really don't believe they feel that they are in competition with us. They are so far ahead that they are now much more worried about tripping up and making a big mistake than they are trying to compete with us because they have accomplished, they can fly these various modules and Soyuz and Progress tankers.

Even their ground support is now capable of handling eight or more simultaneous manned missions in space. When you think of our capability with Johnson Space Center, you know we can do well, but we have never in the past decade been forced to handle that many manned missions independently.

So, there are a number of messages in all of this that are very important. I summarized them in my handout. I don't know which of those you might be interested in, given the late hour. But the value of constant budgets, I should point out that it is not clear to me nor to other people I have talked with whether they have actually spent more on their space station than we have.

What we do know is that starting in 1971 they committed a certain fraction of their budget into five-, ten-, 15-year programs, and what we are seeing now is not miraculous technology but it is technology that they have sustained, and they have not wasted their technology.

So, from some of our points of view, perhaps it is crude—the Soyuz is an example, you can imagine crowding yourself into one of these small capsules and taking six to eight g's on takeoff and landing, and perhaps even being marooned for a half day in orbit, as happened in September.

That is not the best way in the world to travel somewhere, but it works. It is low cost and it is over 900 rockets. And they are willing to make do with that technology to get to their goal, which is the understanding and the exploration of low Earth orbit that Jim Odom was talking about, one of the principal goals of our space station.

In terms of hours on orbit, we are behind. They have the equivalent of 5300, 5400 cosmonaut-days on orbit. And they have used that well. They have made serious mistakes, they have suffered for it, but they have built an experience base that we are going to have to catch up to.

Mr. NELSON. What are those mistakes?

Dr. BANKS. The mistakes in particular, if you look at Salyut II, it broke up on launch. It was launched to orbit, went out of control due to mechanical error.

They have learned basically how to take care of the physiological debilitation that occurs in low Earth orbit. As you are aware, there is diminished capability of the heart muscle. You lose calcium out of your bones and so on and so forth.

As you saw from these two individuals who were in space for more than a year, they have overcome that physiological problem. They literally could send a crew to Mars with insistence on them keeping up with their daily regimen of exercise.

Mr. NELSON. Is that something that we know now because of their experience, or is that something they have guarded?

Dr. BANKS. Well, if you believe Pravda, yes. We have an exchange program. Typically we know the results of what they are doing rather—they are very close with that sort of information.

Cooperation extends to a certain level which tells us what they have done and what the major results are, but to go deeper is sometimes very difficult.

There are a variety of other things that I mentioned in my handout. Perhaps I could just mention those for a moment.

Mr. NELSON. Let me ask you this about the space station. You said maybe '94 launching those components would be on an Energia. Do they have the capability to design and build a totally different kind of space station like that between now and have it operational or have it in orbit by '94?

Dr. BANKS. The hard problem would be building that central core, that 100-ton module, and I would guess at the present time they have design studies for it and they would take about four years to build a module like that.

The other modules are already in existence. They would undoubtedly use the Kosmos Proton modules. There would be no need for others. The truss structure, I don't have any particular information about. The photovoltaic cells, sure.

If you are thinking of the funding and the ramping up of technical effort, those are questions that are hard put and we are probably not in the open area to find the answers to this, but there are people who know the answers.

Mr. Nelson. Go ahead.

Dr. Banks. You recall my background in all of this came out of an advisory committee with NASA, and I advised Mr. Odom's predecessor on scientific uses of the space station. And I found a certain resonance with other members of the committee as they asked their questions.

We have talked about the way that the Soviets have conserved their technology, and I think that there is a message both to the Administration and to Congress that we can't be accused ever again of throwing away the Saturn-type technology.

It was just a profligate waste of technology that would have put us 15 years ahead of the Soviets if we had kept that, realizing that it was expensive, realizing that it was awkward, but still keeping it until we got a shuttle program.

I think the distinguishing feature of the Cosmonaut program is the fact that it is only a small part of their overall space effort.

You are probably aware that they have ten remote-sensing satellites currently that they have beaten out the French Spot-Image Corporation for the remote-sensing mapping of Australia to a three-meter resolution. And you are familiar that Kosmos is marketing both telecommunications satellites, weather satellites, and so on and so forth. This has all been done with a very incremental approach. Their managers and their program leaders know from year to year what is happening.

I want to say a word about the Soviet Kosmos modules in view of some of the discussion this past year which have sidetracked, I think, the attention from the value of having the small modules that you see on the sides there of that particular diagram. We call them man-tended space stations.

Over the past three years there has been quite a debate over whether this country should go in that direction. It became polarized, with people feeling that perhaps this was an alternative to space stations.

The answer is no, there is no alternative to what we are doing, but on the other hand to broaden the base of technology they have different size vehicles for different purposes. These types of small platforms are definitely very valuable, and we see that in the European Space Agency with the Columbus program. They have these free-flying modules.

And it would be my hope that as we get past the initial throes of financing space stations and going forward with its goals, that we would see vehicles, NASA-developed vehicles like this.

If you recall the co-orbiting platform in the initial plan, which has not been discussed recently, in fact that is one step towards an astronaut-tended vehicle that would bring us up to par with the Soviets and give us far more flexibility.

With respect to uses for the space station, I want to support what Mr. Odom has said. There are very well-developed scientific plans.

The National Academy, I felt, was really off the mark with respect to space stations. There is an important segment of the space science community that wants to do microgravity research, there is another segment that wants to conduct life science research, and there are the obvious uses of the space station with respect to attached payloads, either sky-looking or ground-looking. I think that those have not been fully communicated to the entire U.S. science community the way they should.

I guess I am partially responsible for not fulfilling my obligations, leading the original task force. But there are good uses. They are programmed, and NASA, from my perspective now after being off the advisory committees for several years, is doing the best they can in view of the funding difficulties and the uncertainty on how to accommodate some very complex scientific payloads. It is doing the best that can be expected.

I share the disappointment of the 1998 IOC for the permanent habitability. I in fact was very keen to see it in 1994. I made my feelings known. But I think the time for rethinking that has past. We are clearly going forward, and we shouldn't look back in that direction.

Maybe in closing I wanted to say that there is a possible new use for a space station that has come out of my own associations at Stanford University with people like Paul Erlich and Hal Moody, who have been quite open in their feelings about how space and other scientific activities should help solve some of the problems of the world.

Today I was with Mr. Odom to suggest that in fact it's true that more than 65 percent of the population of this world will be under the orbit of the U.S. space station and that there are simple things that space station may do in a different direction than we have looked in the past which could make it a symbol of this country's ability to apply technology to common problems.

In particular, the technologies that we have pioneered, the radar remote images, that is a U.S. technology that is going to be on its way to Venus. We use it in our defense programs.

A simple unit like that on a space station, providing that information directly to the underdeveloped countries, equatorial countries, could make a big difference with the problems they have with deforestation and resource management and so on and so forth.

I hope that as time goes on, this committee will hear proposals from NASA and other agencies of the Federal Government proposing this type of use for the space station. It certainly takes it out of the realm of the academic science—I would include even our interest in global habitation as being somewhat academic—into the realm of operational remote sensing. That really could make a difference to countries that don't participate currently in our international space station.

I think that plus the fact that you have my written document in front of you, I would hope that gives you at least an idea of the information that I have on the Soviet space station, and I would certainly be happy to answer any questions you might have.

[The prepared statement of Dr. Banks follows:]

TESTIMONY TO THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS

LESSONS TO BE LEARNED FROM SOVIET SPACE STATIONS

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February 28, 1989

Mr. Chairman and Members of the Subcommittee. Please let me introduce myself. I am Peter Banks, Professor of Electrical Engineering at Stanford University. I am here to discuss the Soviet Space Station Program and its relevance to the NASA plans for the U.S./International Space Station. My expertise in this area derives from my past work with NASA's Task Force on *Scientific Uses of Space Station and from a* special report on Soviet activities in space I helped prepare for Dr. James Fletcher two years ago. In addition, I am a space scientist and have participated in three previous scientific missions with the space shuttle and I am now preparing experiments for two additional shuttle missions set for early 1991.

My purpose today is to give you personal thoughts about the Soviet space station program and its relevance to our own plans. Much of what I will say has been described in a February, 1989 Scientific American article co-authored with Dr. Sally K. Ride. I would like to request your permission to include this article, and a copy of my written testimony, in the record of this hearing.

There can be no doubt that the Soviet space station program and its associated cosmonaut activities is far ahead of our own in terms of overall functionality and capability. Let me quickly recount some highlights as background to what I feel we can learn from their activities:

- The SL-4 rocket is a key element for transporting humans to space. With a 7.5 tonne lift capacity to low earth orbit this booster was first put into operation in 1963. The SL-4 is a man-rated vehicle with more than 900 launches over the past 30 years. It carries the Soyuz modules, the Progress cargo ships and small satellites to low earth orbit. Its launch success rate is currently better than 95%.
(Figure 1, provided by Nicholas Johnson of Teledyne Brown Engineering, shows the current Soviet launch vehicles with payload capacities, lift-off weights, and lift-off thrust.)

- The Proton rocket booster system was developed in the mid-1960's with a first launch in 1968. It has a payload of 20 tonnes and is used, among other things, as a cargo and space station module delivery vehicle. The Proton launch success rate is about 93%.

- The world's first space station was the Soviet Salyut-1, launched in April 1971. Four additional Salyuts were flown before 1977 in what might be called a "Skylab-mode"; i.e., all provisions, thruster fuel, and other consumables for the visiting cosmonauts were carried to orbit with the Salyuts. These Salyut early missions were principally devoted to technology development with relatively limited occupation periods by one or more visiting crews.

- Starting with Salyut 6 in 1977, dual docking ports were added, permitting two spacecraft to mate simultaneously with the Salyut space stations. In 1978, automatic rendezvous and docking of Progress tankers and cargo ships began. Approximately two tonnes of cargo could be provided by each Progress. Automatic refueling of the Salyut 6 was demonstrated. This combination of services permitted cosmonaut space station crews to remain in space indefinitely, if there was a need to do so. It also enabled crew exchanges and opened the way to short term cosmonaut visits. The first fully automated transfer of space station thruster propellant from a visiting space tanker was undertaken in this period.

- Uses of Salyut 6 included a variety of space technology and microgravity science-related investigations. These included studies of long term human endurance in space and the operation of various furnaces for creating a variety of alloys, crystals and other materials. This latter work has led to publication of the only existing textbooks on space microgravity materials effects.

- Salyut 7 replaced Salyut 6 in 1982. Various incremental improvements were made, but the basic model of the space station remained the same. Further work included continued military observations and new scientific measurements. The space traffic to and from Salyut 7 shows that at this time the Soviet operations system was capable of controlling at least three simultaneous manned spacecraft at the same time.

- In the early 1980's the Soviets were observed testing a small space plane. This was initially thought to be a model of a space shuttle (a people plus cargo reusable vehicle), but Department of Defense experts now believe it was a model of a small, reusable vehicle intended to carry 4 to 6 persons to low earth orbit along with a small cargo. The SL-16 ELV is thought to be the launch vehicle for this new transport system. The Soviet space plane is very similar to the early U.S. Dynasoar space plane and the planned French Hermes space vehicle. A possible full scale test was reported by Aviation Week in 1987.

- A large Kosmos space module was used with Salyut 7. It is thought that this 20 tonne vehicle, launched by the Proton booster, could act as an independent, short term space station, if such a facility was needed. This vehicle could be easily launched into polar orbit, for example. (Figure 2 shows a Kosmos Module, and Figure 3 presents a Soyuz, Salyut 7, and Kosmos Module link-up.)

- In 1985 the Salyut 7 space station was disabled by a combination of equipment failures. In June a rescue mission was organized and two cosmonauts were able to put the station into operation with extraordinary perseverance while enduring very harsh conditions in space.

- The Mir space station was put into orbit in February, 1986. Outfitting of the modules was done at a leisurely pace. Many internal improvements were made in station operating equipment, including more hospitable crew quarters and modern computers. The outstanding new feature of Mir was its new multiple-payload docking port. A curent view of Mir is shown in Figure 4, along with the Soviet shuttle Buran. Up to six space vehicles or modules can be docked to Mir at one time. In 1989 Mir will add two large (20 tonne) modules plus two new Kavant-size (11 tonne) modules. Figure 5 shows this prospective configuration, together with a possible docking port to the Soviet shuttle. Soon after this, two smaller Kvant modules (11 tonnes each) are expected to be attached to the remaining two docking ports. In its full configuration, the total mass of Mir will be on the order of 120 tonnes. Up to 36 kW of electrical energy will be available from solar panels. A Soviet TV audience was given a full view of this final configuration in early 1987.

- Communications to the Mir station involve both conventional direct to ground sites in the Soviet Union and to support ships as well as a Soviet data relay satellite system similar to the U.S. TDRSS satellites. (See Figure 6.) This system is still under development, but when complete will permit Mir to be in almost constant contact with the Kalingrad Operations Control Center near Moscow.

- Soviet scientists have stated that in terms of life science studies, they feel they understand problems of physiological degradation in space, and that their focus is on mental health and performance; i.e., individual psychology. In addition questions of the sociology of groups of individuals separated from terrestrial activities become openly discussed.

- 1987 and 1988 Westerners were given extensive tours of the Star City cosmonaut training facilities near Moscow and the Baikonur Cosmodrome near the Caspian Sea. Facilities supporting the space station program were discussed and the first mention was made of cosmonauts being trained for the Soviet space shuttle.

- In August, 1987 the Soviets launched a 15 to 20 tonne Earth resources and ocean survey satellite (Kosmos 1890) into a 71° orbit. This was the largest civilian Earth survey spacecraft ever launched, according to Aviation Week. This platform was stated to have many of the same instruments as those desired for the U.S. Polar Platform to be launched in 1994; i.e., a SAR radar, an imaging TV system, optical sensors, and so forth.

- In August, 1987 the Soviets were operating six cosmonaut-related spacecraft in orbit simultaneously. This included Salyut 7, Mir, Kavant, a space tug, a Soyuz and the Kosmos 1686 module docked to Mir. Progress tanker resupply missions periodically raised the total number to seven.

- In October, 1987 the first large module (Kvant) was delivered to Mir via a Proton launch and orbital flight. It contained various flight support equipment, including control moment gyros and an externally attached scientific payload section.

- In May, 1988 the Soviets tested the Saturn-V class Energia heavy lift launch vehicle, capable of lifting ~150 tonnes to low earth orbit. The booster is modular. The large core rocket uses liquid oxygen-hydrogen fuel. In addition, the Energia has four externally mounted smaller rockets to gain extra thrust. These added rockets are the first stage of the SL-16, which is used for various other satellite launches.

- In November, 1988 the Soviets successfully launched and tested their space shuttle using the Energia booster. No crew was aboard, reminding us that the U.S. shuttle could have had the same capability were it not for an early decision against this added capability. The flight was announced in advance and given national Soviet TV coverage. A manned flight of their space shuttle is planed for early 1989.

- In December, 1988 a new time in space endurance record was recorded: Cosmonauts Titov and Manarov returned to Earth after more than a year in orbit. The physical condition of the cosmonauts upon return to Earth was found to be acceptable Soviet doctors and a spokesman stated that the results indicated that humans could undertake a one year trip to Mars if proper physical exercise was practiced during the voyage.

- By the end of 1987 the Soviets had accunulated more than 5400 cosmonaut-days in orbit. The equivalent accumulated U.S. presence in space is approximately 1600 astronaut-days This time in space has given Soviets great confidence about their ability to design and undertake various ambitious activities, including construction of large space structures, the ability of humans in EVA to make space station repairs, etc. As announced in January, 1989, the Soviets will be testing their own version of a Manned Maneuvering Unit on Mir in April or May of this year.

- Future plans for space stations have appeared in Soviet literature. Figure 7 shows one provided by N. Johnson of Teledyne Brown Engineering.

Taking this partial list of Soviet space activities as a basis, I would now like to turn to the question of what can we learn with respect to our own plans for a space station. I would like to summarize these as short statements:

The Soviets have built a powerful manned space program using a very conservative engineering systems approach. Improvements in flight hardware have come incrementally and are based on previous experience. Technology, once proven, is only discarded after extensive use. The Soyuz vehicle and Proton boosters are good examples of this.

The Soviet experience makes me question the wisdom of requiring our own space station program to be a show case of new, not well developed technologies. This includes advanced automation, robotics, and artificial intelligence. These advances are not yet fully incorporated into our terrestrial technologies. In today's world of government hardware procurement I question whether you reasonably ask any aerospace company to assume the technological risk involved without incurring very high costs. I would also ask you whether some of the inflation of space station costs over the past several years aren't related to congressional mandates for automation and robotics, in particular.

The Soviet space stations have evolved in response to new needs and capabilities. Small things have grown larger. Risk has been minimized. There is evidence of far less engineering theoretical and analysis study than we require in our own space systems.

With respect to our own programs, there is an urge to find new solutions using cutting edge technology. But, what is our goal with the Space Station? Why have we rejected a modest repeat of Skylab as a foundation or building stone in favor or the much risker, later, and more capable Freedom Space Station?

The resources required to support the cosmonaut-related space activities are a small part of the overall the overall Soviet space effort. Only 10 to 15 launches per year are needed, out of a total of nearly 100 major rocket flights from Plesetsk and Baikonur Cosmodromes. In addition, transportation to their space station spreads risk between cosmonaut transport (Soyuz) vehicles and unmanned, automatic cargoships. These vehicles do the work required in a basic, no-frills way. There are no immediate plans for them to use the space shuttle.

The question of how we transport humans to space is a key issue affecting all aspects of the U.S./International Space Station. Reliance upon the space shuttle puts us in an exceedingly risky position. Humans and cargo have different values and safety requirements. If our goal is to deliver humans to space, then we should build a vehicle specifically for this purpose. The Dynasoar plans were right in terms of basic concept. Our subsequent difficulty lay in not having the foresight to see that this was a better solution than the shuttle for the purpose of transporting people to and from space. The prospective Soviet space plane, and the French and Japanese space planes, can do this very well. By keeping the number of crew small, devoting a far less complex booster to putting the plane into orbit, and by allowing it to be reusable, one gains enormous advantage over the situation we now possess.

Along these same lines, it is clear the the U.S. Aerospace plane won't have an important role in supporting human presence in space within the foreseeable future. The concept involves risky, new, high cost technologies. What the Space Station program needs for getting people to and from space is is a stable, proven method of human space transport; i.e., dependable vans, not Indianapolis racers.

Risk to cosmonauts is recognized and accepted as part of space activities. A rapid means of escape from space has been provided to every cosmonaut on every space station flown.

As a matter of national policy, we should provide easily accessible escape vehicles for every person on our space station.

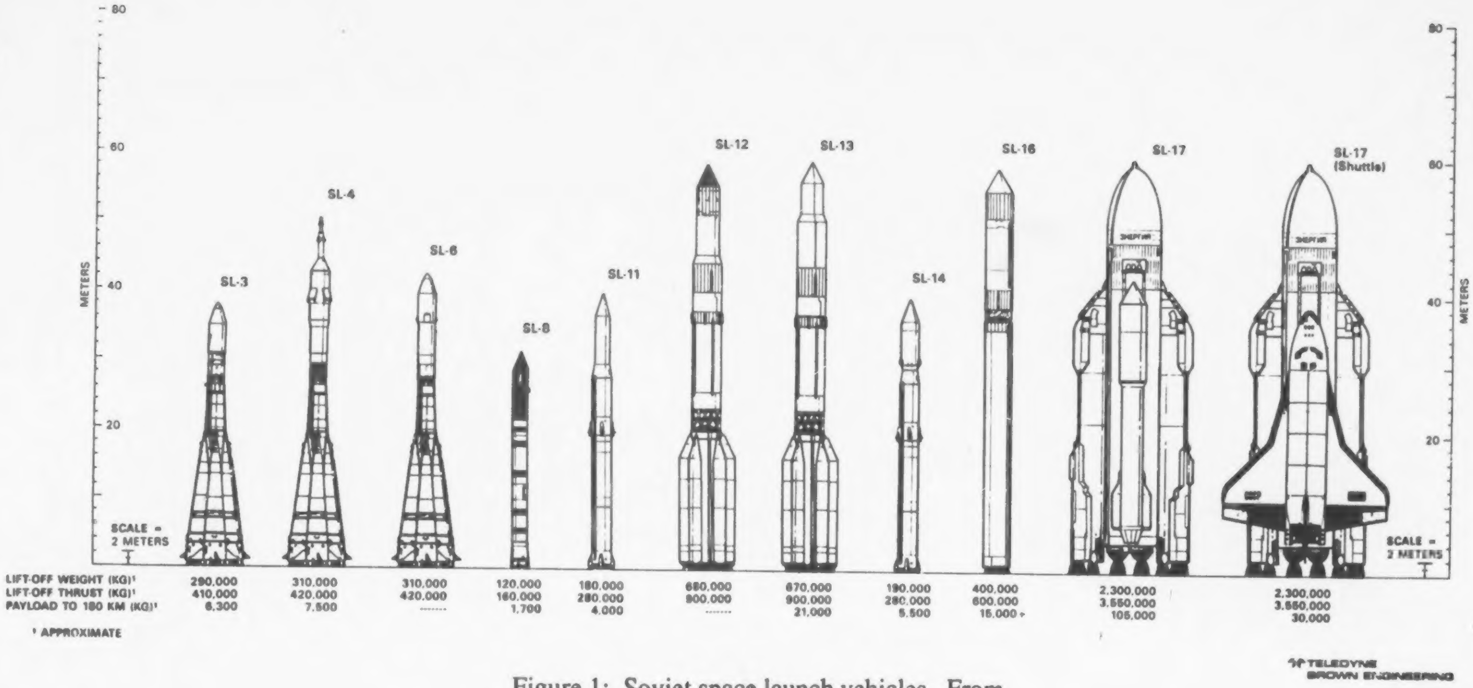
Soviet Kosmos modules give an extra dimension of versatility to the Soviet space station program. Delivery of these can be made using the Proton booster and the modules possess suitable command and control avionics permitting them to either fly as separate missions or to be mated with the space station. ESA has recognized the importance of this in their own Columbus program. We should do the same. The closest equivalent on our drawing boards is the so-called Commercially Developed Space Facility. This is, unfortunately, a good example of how, as a nation, we satisfy ourselves with technology concepts rather than operational reality. Man-tended space platforms have important roles in space science and technology. To view them as viable alternatives to a much more capable space station is wrong. In fact, the opportunity to gain space operations experience with CDSF's should be an essential part of the Space Station program. As we develop the advanced technology required for Space Station, we should embrace the intermediate technology step of the astronaut-tended facility. There is much to learn about all phases of space operations of this type, and the three or four years between putting a CDSF into space and the arrival of the larger and more capable Freedom station would be valuable to both NASA as an operating agency and to the scientific community which desperately needs access to space.

Uses of the Space Station. Soviet development of their space stations has emphasized growth of operational capabilities and supporting technologies with only minor attention being given to a fully developed usage rationaly. In this country we insist on full justification of the Freedom station on the basis of demonstrable, valuable science and applications. I don't believe that we should back away from demanding high quality science, but I wish there would be more recognition of the need to learn how to do things efficiently and capably in this new facility. Space Stations aren't submarines nor bases in Antarctica. They exist in a remote, debilitating environment which must be probed with caution. Operations and science must be prepared to learn how to take advantage of the expected and unexpected opportunities offered by Space Station. Premature, overly complex experiments and activities will certainly escalate costs and complexity. Please give NASA and the space station users a chance to evolve their capabilities before demanding too much.

A New Use for Space Station? Along this same line, I must ask an important question of my space science colleagues, NASA, and Congress. After the long years of planning science activities for the space station, it is possible that we have ignored one truly important use of space station? One that would make the Freedom Station a symbol of the value of modern space technology to the average person of this world? In particular, I note that the Freedom Station will pass over more than 60% of the world's population each day. Furthermore, that population lies in the equatorial belt of the world where developing countries are facing terrible problems of population growth and environmental destruction that within just a few years will threaten our own national security. What might we do with Freedom Station to mitigate these global problems? With all respects to my scientific colleagues and this sub-committee, I suggest that one, modest step forward would be to equip the Freedom Station with current technology microwave radars and optical imagers to provide daily, operationally-oriented remote sensing data directly to equatorial nations. This rapidly delivered information could be used in many important ways. Land use management, agricultural development, up-to-date forest and crop maps, emergency evaluation of floods and disasters; these and many other applications would give developing nations tools that are unavailable to them today. Why not embark in this relatively simple program at the same time as we equip our polar platform with the best instruments needed for scientific study of the changing Earth? Have we forgotten that applications such as operational observations may have more immediate importance than long-term, contemplative scientific study?

In closing, I appreciate the opportunity to present this analysis of the Soviet cosmonaut space program. Indeed, we have much to learn if we are willing to think about the fundamental things we are trying to do with our own space station.

I would be pleased to respond to any question you might have with respect to my comments.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¹ APPROXIMATE
TELEDYNE BROWN ENGINEERING

Figure 1: Soviet space launch vehicles. From Nicholas Johnson of Teledyne Brown Engineering.

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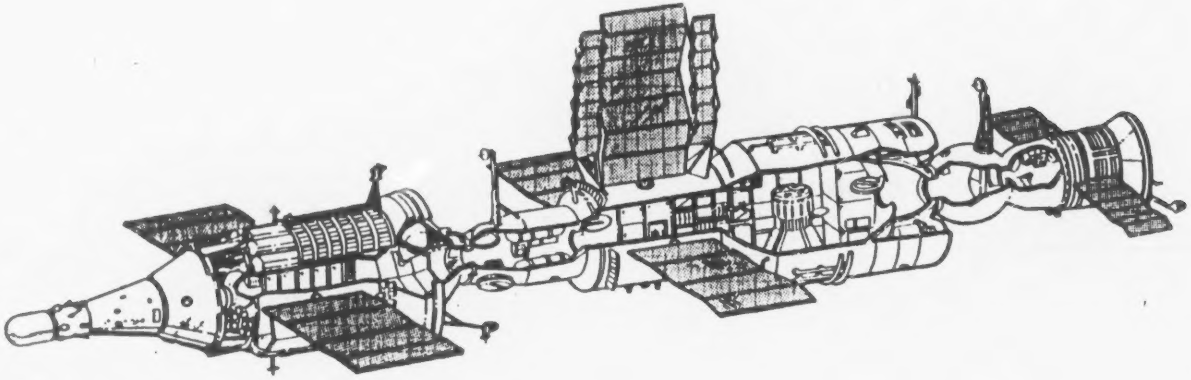

Figure 3: Illustrating the link-up of Salyut -7, a Kosmos module, and a Soyuz vehicle. From Nicholas Johnson, Teledyne Brown Engineering.

TELEDYNE
BROWN ENGINEERING
1250 ACADEMY PARK LOOP
COLORADO SPRINGS, COLORADO 80910

B 11

Pressurized Volume:	~70m³
Power:	~3 kw
Weight:	~44,000 lbs.
Length:	~43 ft.
Width:	~13 ft.

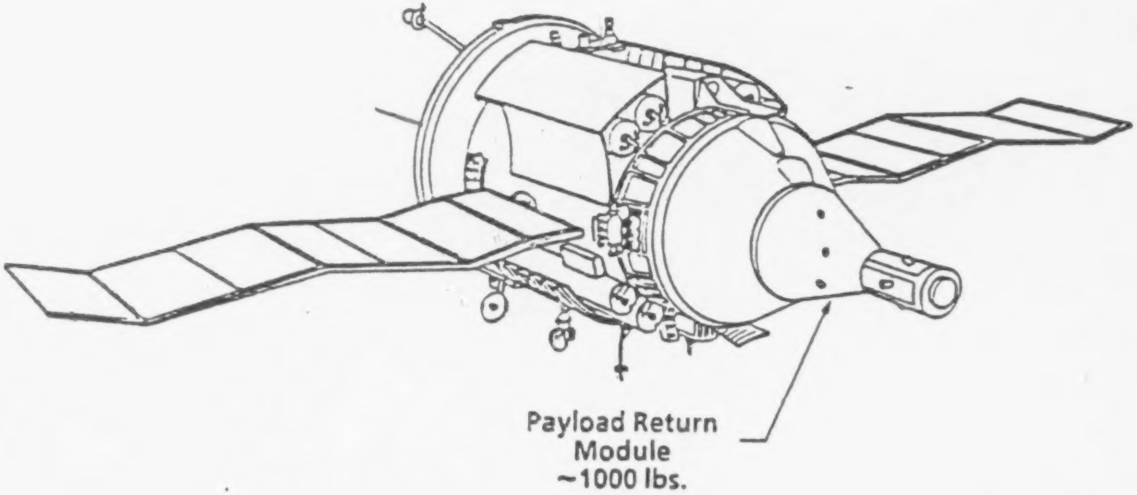
Payload Return
Module
~1000 lbs.

Figure 2: Illustrating a Kosmos module used as a free-flying space vehicle.

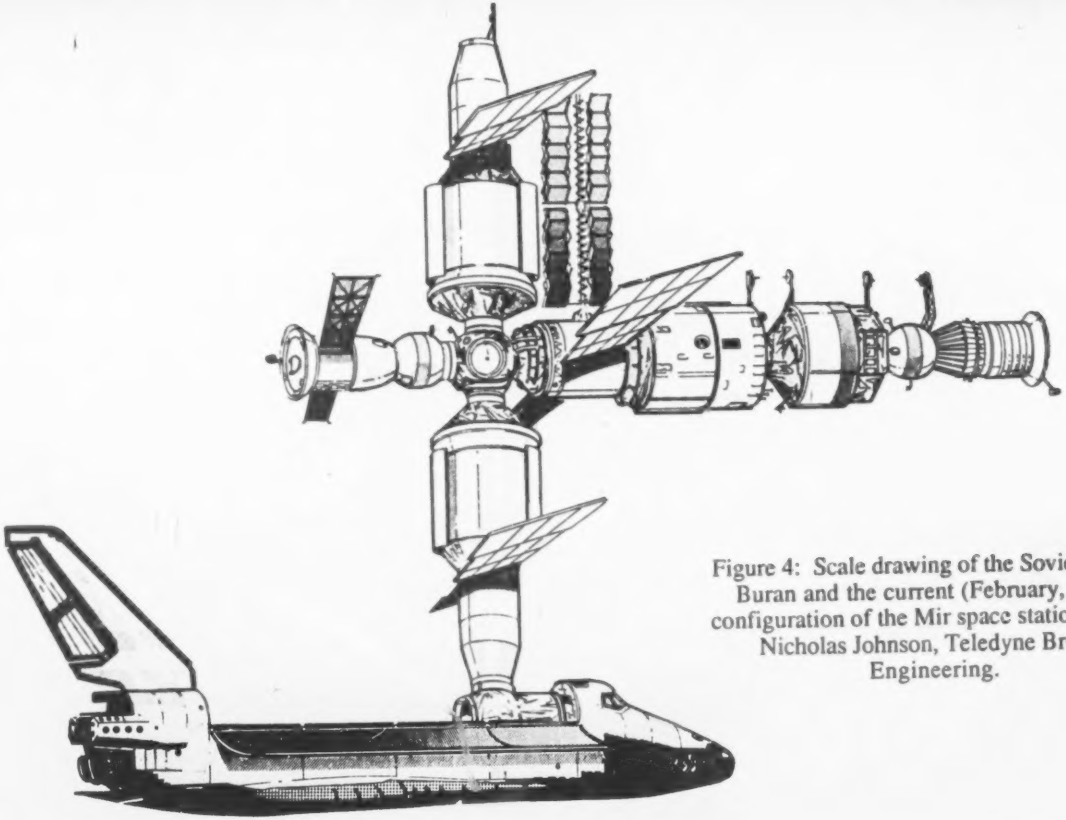

Figure 4: Scale drawing of the Soviet shuttle Buran and the current (February, 1989) configuration of the Mir space station. From Nicholas Johnson, Teledyne Brown Engineering.

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BROWN ENGINEERING

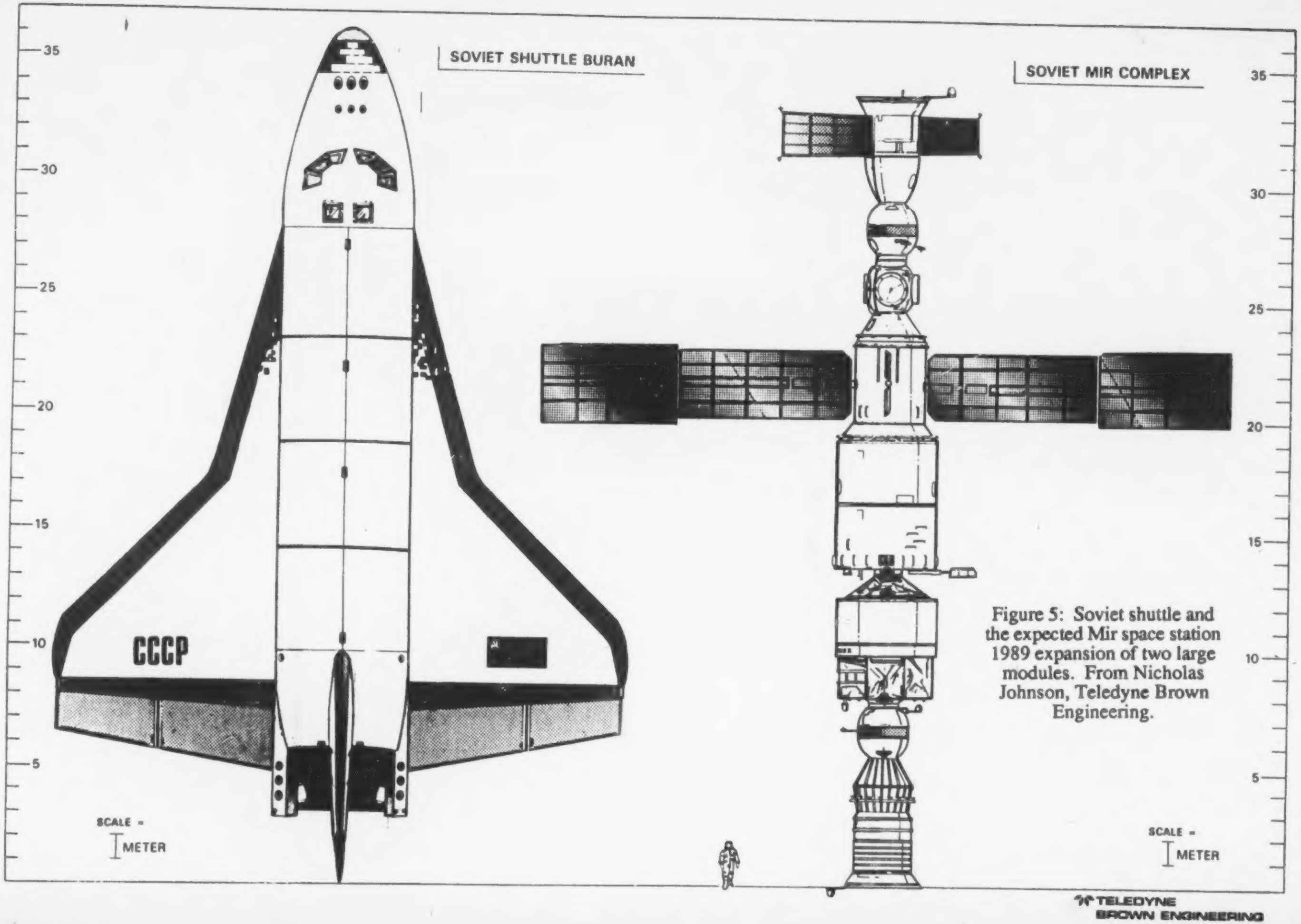
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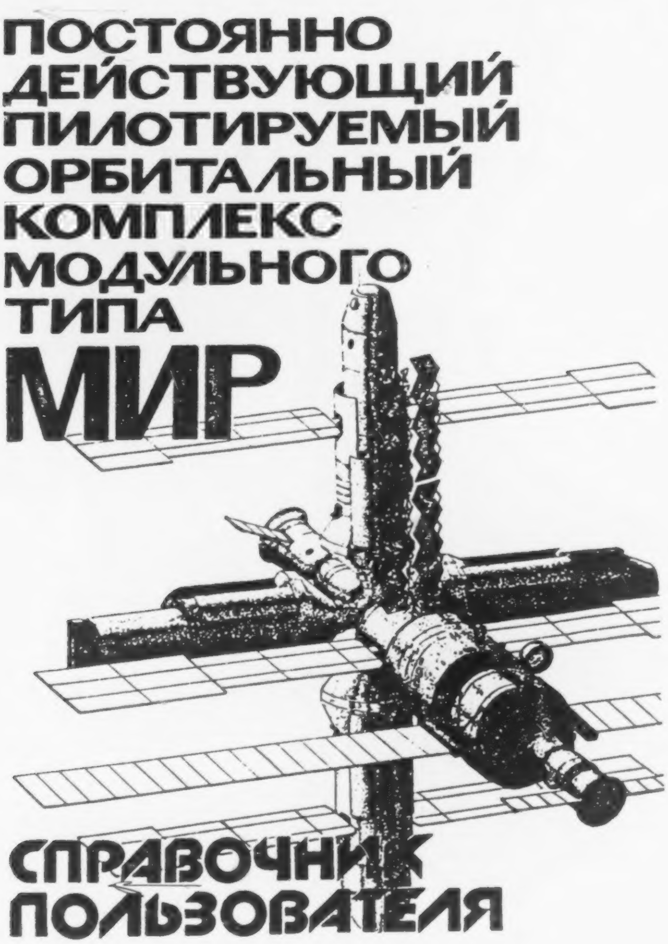
Figure 5: Soviet shuttle and the expected Mir space station 1989 expansion of two large modules. From Nicholas Johnson, Teledyne Brown Engineering.



ПОСТОЯННО
ДЕЙСТВУЮЩИЙ
ПИЛОТИРУЕМЫЙ
ОРБИТАЛЬНЫЙ
КОМПЛЕКС
МОДУЛЬНОГО
ТИПА
МИР

СПРАВОЧНИК
ПОЛЬЗОВАТЕЛЯ

Figure 6: A possible view of the completed Mir station in 1990, including the two expected large modules and two smaller Kvant-type modules docked to the multi-port adapter. The original Kvant module is shown at its current axial docking port. Two Soyuz-class vehicles are also shown. Provided by Nicholas Johnson, Teledyne Brown Engineering from Soviet sources.

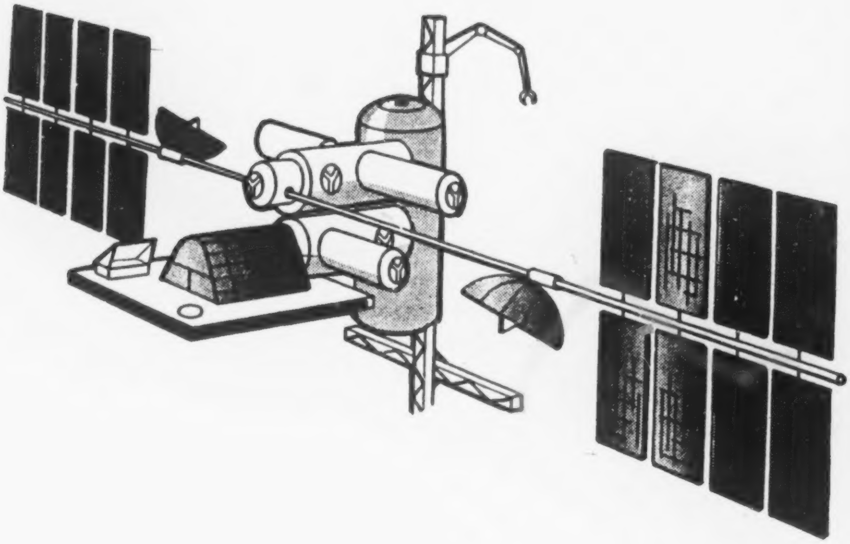


Figure 6: Soviet concept of a mid-1990's space station to be launched with a variant of Energiya. The core of the complex is a 100 to 200 tonne module. Smaller modules can be added according to need. An enclosed service area is also shown as part of the complex. From Nicholas Johnson, Teledyne Brown Engineering.

Mr. Nelson. Any questions from the committee?

Mr. Nagle?

Mr. Nagle. I had to step out to be with some constituents, and I apologize, Mr. Banks.

But I was curious about—I just came in, I think, as you were completing—the Soviets are putting up another station in '94; is that correct?

Dr. Banks. It is very clear from the Soviet literature that the Mir station is perhaps the last of what you could call the Salyut style, these long, thin, cigar-shaped things they have used so effectively. And now that they have the Energia, this large payload capable of a new configuration with crew sizes on the order of 15 to 20 persons in low Earth orbit.

Mr. Nagle. I am searching my memory bank, but I thought the lift capability of the Soviet heavy-lift launch vehicle payload capability was about 182,000 pounds. Am I in range?

Dr. Banks. The best guess we have now is about 100 to 120 tons. That is just about the payload for that central core. There is that ambiguity there because they certainly don't tell us everything.

Mr. Nagle. 100 to 120 tons?

Dr. Banks. That's correct. That is about 200,000 pounds.

Mr. Nagle. Okay. How many launches would it take—what is it called?

Dr. Banks. The Energia.

Mr. Nagle. How many lifts does it take to put that thing up?

Dr. Banks. The central core you see in the diagram there would take one launch to put that in orbit. It would then be met with a live-in crew. I am hypothecating based on how they have done other similar missions.

There would be either a shuttle or a series of Soyuz that would bring people up and assume permanent habitation and be the construction crew that would be there when they guided their modules in.

They do have the ability—perhaps you missed that—for automatic rendezvous and docking. They developed that in about 1978. And those are 20-ton payloads they can bring aboard in that fashion. And I would suspect over a period of about a year you would see things like that put together and they would be very careful in doing that. They would check it out and go one step at a time.

Mr. Nagle. Comment on our lift launch capabilities for the space station in comparison to theirs, if you would.

Dr. Banks. Well, we are utterly tied at the present time to the space shuttle. It was degraded after the Challenger accident. I think the model that I have seen for NASA have payloads that range from, depending on volumes—not just mass, volumes as well—to 44,000 pounds, about 20 tons.

Mr. Nagle. Can you get the integrity of construction by taking smaller packages? I think NASA is currently projecting 19 flights—Mr. Odom, correct me if I am wrong—can you get the integrity of construction by taking smaller payloads 19 times, or do you get more integrity of construction if you do it in fewer lifts?

Dr. Banks. That is a good question. I guess I am not the expert in this. The main tank you see there would be a Skylab-type technology, and I think it would be simpler to build that than it would smaller modules.

But the modularity, it's a vertical modularity. I didn't discuss this in view of the time available to the committee—but one rocket will be modular to the next rocket and one module will be modular *to the next space station.* And they have standardized their rack sizes and power systems, and they do have practice hooking these things together.

Mr. **Nagle.** What, in your opinion if you have one, would the addition of U.S. launch capability with Shuttle C have in fact on our capacity to develop our space station in operation?

Dr. **Banks.** Several years ago I and several other people from the space science community suggested that a Shuttle C equivalent could put a spacelab-type space station into low Earth orbit by '93 or '94. But it didn't include the capability of modules as indicated here because we haven't developed that technology.

Mr. **Nagle.** Is the absence of Shuttle C handicapping our ability to deploy relatively rapidly and perhaps less expensively the space station?

Dr. **Banks.** It is a reconfiguration. I know there have been several studies within NASA. Several years ago, the Hook study, which indicated that you could materially increase the speed of deployment, certainly.

Mr. **Nagle.** I guess what I am concerned about, you know—and you understand despite my conversation with Mr. Odom today, I support the concept of the space station, and I want to know what I am paying for.

But beyond that, I am concerned about our launch capabilities, given an accident or if it's shot down or not even a catastrophic accident with the shuttle, it would just seem to me to really put us back behind the eight-ball, even worse behind that ball than we were in 1987 when the Challenger blew up.

Dr. **Banks.** It's a risk. There is no doubt. Throughout our space station program.

Incidentally, I should point out this is the fifth space station program this country has tried to get under way, which perhaps as a Nation doesn't do us great credit. But I think Mr. Odom and others are trying as hard as they can to actually get one into space.

We are not just hypothecating one, but there is no doubt that this launch problem is the limiting risk that we see. It's easy in simple ways to have a disabled orbiter, not a dire catastrophe, but one where you have a stand-down of three months, six months while they reassess what the problems are.

If that happened during our launch sequences, we will have to be very careful when and if it happens, and it could or could not be a problem.

Mr. **Nagle.** The bottom line on this, one of the lines that we have to look at is the capacity to deploy the station itself necessarily depend on the presence of man just to get some of the materials up or significant portion of the materials up and therefore you don't have the risk that you would manning the ship. Is that fair?

Dr. **Banks.** Absolutely. The smaller payloads tend to be more economical in terms of cost and risk of loss.

As you know, the Soviets have larger numbers of these Proton boosters available and replicate their payloads very rapidly. So, loss is not a major factor.

Mr. NAGLE. One other question—and thank you for your answers—and either to you or to Mr. Odom.

The 19-launch schedule that is our current estimate, does that mean the launch schedule with an ASRM or an RSRM?

Mr. ODOM. That is with today's—it's without the ASRM.

Mr. NAGLE. Thank you.

Thank you, Mr. Chairman.

Mr. NELSON. Is basically the difference between the two programs is that we have limited ourselves to a specific launch vehicle?

Dr. BANKS. You are asking, I would say, the difference between the two programs, I think, which is the thrust of what you were saying, is their commitment to a long-term exploration, cosmonaut exploration in low Earth orbit, they begin, they dropped out of the Apollo moon race. They realized that they couldn't compete with us, and they put their prime emphasis as part of a 20-year program to send successive vehicles into low Earth orbit.

Their initial ones were for short periods: two, three, four weeks. They had up through 1978, they went like we did with Skylab.

We sent Skylab up fully provisioned, with water, food, and electrical power. We went up and stayed there on three separate occasions. They did the same with their Salyuts.

The difference in the program is that they are compounding their technological expertise. They are building in an incremental way things like Protons, the Kosmos modules, as part of the program until they are really set and have a definite need to move out to the next level of volume, size, crew size, electrical energy.

Unfortunately we didn't do that, and we became, I think, overly committed to a transportation vehicle rather than the goal of what we were trying to do in space, which was to gain experience in low Earth orbit, to learn how to operate equipment and how to accommodate to weightlessness and how to prepare for whatever the next stage is.

And we don't know what the Soviet next stage is, but it could very well be going to Mars. They will be very well equipped to go to Mars around the turn of the century. We will be probably fairly poorly equipped at that point, and focusing our technology if we were to even be partners in that undertaking.

Mr. NELSON. Had Skylab's orbit not degenerated so that it came back, would we have been able to experience on orbit, that being our first space station, being anywhere ahead of where we are now, aside from the obvious additional crew time and so forth?

In other words, could we still have Skylab there right now and could we have expanded on the Skylab given the fact that our vehicle was the shuttle?

Dr. BANKS. I think hypothetically the answer is yes. Had there been a strong presidential and congressional commitment to the program. I am not sure, in view of the costs of the shuttle, that that commitment would have appeared. You can speak better to that than I.

Mr. **Nelson**. Mr. Odom, do you have any questions for Dr. Banks?

Mr. **Odom**. No, sir.

Mr. **Nelson**. Dr. Banks, do you have any questions for Mr. Odom?

Dr. **Banks**. No.

Mr. **Nelson**. Any other members have any further questions?

[No response.]

Mr. **Nelson**. Mr. Skaggs?

Mr. **Skaggs**. Thank you, Mr. Chairman. I am sorry I am a very late arrival this afternoon.

As I understand it, the issue of the heavy-lift vehicle and other similar notions has been given a good deal of discussion already. I don't know whether the question has been posed explicitly. If it has, I will read the record on it.

Particularly, Mr. Banks, a candid assessment of whether proceeding on the schedule now proposed for construction and operation of the station is practicable without that additional lift capability being put into the system?

Dr. **Banks**. Several years ago I argued that the equivalent of Shuttle C would have been a very effective way to speed up the pace of deployment. The decision was made two to three years ago not to do that.

What we see now is a very livable schedule and one that balances the available funding and the ramping up of technological efforts. And while it may be possible to abbreviate the launch schedule somewhat with the Shuttle C, it is going to introduce new costs in its own way. And someone is going to have to make up their mind whether they are going to pay dollars or live with the time schedule that has been developed by Mr. Odom and his colleagues.

I think that it is really the obligation of the country and Congress at the present time to give Mr. Odom all the support they can to let him to get to that schedule and start building things as quickly as he can and not delay things by hopes of Shuttle C or another heavy-lift vehicle, which I firmly believe should be developed but I don't want it to hinder what is already on the way, so to speak.

Mr. **Skaggs**. Mr. Chairman, again I don't want to cover territory where we have been already been over it. If you have already examined the realism of the existing shuttle manifest for the years that the station is proposed for construction, and whether those are realistic, again I will look at the record when it is available.

Mr. **Nelson**. Let's save that for another day because I think you have got a whole subject matter that I want you to get into. So, I would like for you to get into that in depth.

Mr. **Skaggs**. Thank you.

Mr. **Nelson**. I don't want this hearing to close with the impression that we in any way are not exceptionally supportive of this project. We have fought and bled, and we have been in the wars. And somehow we have been able to keep this thing going.

But hearings like this just leave a bad taste in our mouth when questions that are legitimate questions cannot be answered. This is what an Administration space policy is supposed to be for. And you are to articulate that policy, and you can't articulate that policy, Mr. Odom, because there is none.

There is an attempt to do these kinds of things which you cannot answer because you do not know the answer. And this committee is going to require the answers. That is our responsibility. And that is our responsibility that we hold the executive branch of Government accountable that they answer these questions. And we are going to do that.

Now, lest there be any misinterpretation of our hard questions or our impatience as expressed here today, that that in any way diminishes our support or our enthusiasm that this is the direction that America should be going, I think Dr. Banks has raised a number of questions whether or not this is the ideal—and I am not sure it is—but this is where we are. And we have got to move out.

Now, there are a number of things that we ought to look at as we move out, should we get moving with Shuttle C. We are going to have a hearing on exactly that subject, particularly in light, I think, of the Air Force stepping down on its timetable on an ALS, should there be some additional Progress-type vehicle they could supply without having it manned that is the size of the Shuttle C.

I think we need to crank that into the equation as we are looking at the supply, what is most efficient. And then, of course, all the other questions that go with this: When does Phase B start? How are the solar dynamics coming along? Can you launch this thing with the Titan III in polar orbit? Is there a way that you can go to Shuttle C and still go out of Kennedy and dog-leg up?

So, we want to get into a whole bunch of these things. But the problem, when we go out and try to sell all this to our colleagues in this fiscal environment that we are in, they want to know specifically what it is going to cost.

And they don't like this kind of stuff that you use, the airport development trust fund, in large part keeping big reserves so that you can balance the budget—I mean so that you can lessen the deficit. My colleagues don't like that kind of fiscal policy, and so they are not going to like this kind of fiscal policy.

So, let's get it out on the table and let's move forward and let's get America in space with a space station so that we can start planning.

By the way, speaking about the Soviet capability of going to Mars at the turn of the century, that of course would belie Secretary Gorbachev's statement of cooperation, because if they are going to have that capability, why would they want to share that prestige with the United States? And we are going to explore in hearings in the future.

MIT and Dr. Franklin Chang-Diaz are developing a rocket at MIT right now, a plasma rocket. If that were to be perfected, that would take us to Mars in one or two months, not 10 or 12 months, and it would also take away the weightlessness because you can have a constant acceleration and then a constant deacceleration once you have passed the halfway point. So, you would not have the physiological stresses on the body there.

But maybe we are looking at long, long term. Maybe we are looking well on into the next century for that kind of technology. But we are going to explore that.

So, it has been a most enlightening hearing, and we thank you. The meeting is adjourned.[1]

[Whereupon, at 5:30 p.m., the subcommittee was adjourned.]

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[1] Appendix 1 contains additional answers to questions asked of Mr. Odom following this hearing of Feb. 28, 1989. See p. 1129.

1990 NASA AUTHORIZATION

MARCH 1, 1989

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met at 9:50 a.m., pursuant to notice, in room 2325, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Present: Representatives, Nelson, Volkmer, Mineta, Torricelli, Nagle, Skaggs, Sensenbrenner, Lewis, Packard, Robert Smith of New Hampshire, Larmar Smith of Texas, Rohrabacher, Morella, Schiff, and Walker.

Mr. Nelson. Good morning. We continue with our third of the series of authorization hearings, and we are going to hear today from two of the key offices in NASA, from the Office of Space Science and Applications, and then from the Office of Space Flight.

We start this task in our authorization hearings with a great deal of confidence and optimism that we are just about on the edge of a new decade of tremendous advancement in space flight and science.

I had a meeting yesterday with Admiral Truly and complimented him and told him how much the success of his office was going to make it so much easier for us. You know the kind of battles that we had to go through last year, and they were tough. They are going to be tough again this year, but there is a major difference in our environment, and that is that America is back where she belongs. American has reclaimed the high ground and we are back in space.

And I think it's appropriate that Admiral Truly and his team of Center Directors were selected to receive the Goddard Trophy and will be receiving that on March the 10th.

Now Admiral Truly and his team may not be at the Goddard Dinner to receive that because they may be at the Cape on that specific day launching. If we get it off on the morning of the 10th, then they can be back in Washington to appropriately receive the trophy.

This year is going to be a banner year for science. We are going to have three science related major launches, Galileo to Jupiter, Magellan to Venus and then the Hubble Space Telescope. That telescope is going to help us pierce seven times deeper into space. Information is going to pour back to us that we have never been able to see.

Now thanks to Dr. Fisk and to Admiral Truly, we find ourselves in the circumstances that we are now facing, much more optimistic circumstances. They in large part have been in the driver's seat to help bring NASA back into the flight status as well as to preserve our science missions under extreme duress.

Now in the midst of all this optimism, however, let's don't ignore the fact that we have a tough, tough budgetary situation. The $4.7 billion that is requested by the Office of Space Flight and the $2 billion that is requested by the Office of Space Science and Applications is simply not sufficient to undertake all of their activities. Their budget request ought to be much higher than it is, and yet you know the world that we are living in.

So I think it's up to us on this Committee that we understand the logic of their request and then figure how we are going to present this to our colleagues, and that is going to require, Mr. Fisk and Admiral Truly, the best of communication between you all and us.

Several questions come to mind as we look at this budget request.

With your science initiatives, is this going to help us keep competitive? It is the intention of this Committee that we want to be competitive in space. We want to be competitive against our foreign competitors.

Well, if that is the case, why did NASA strike ACTS, the Advanced Communication Technology Satellite from the budget?

It is the intention of this Committee that we want to remain at the forefront of basic research.

So then why did NASA cut the Gravity Probe-B?

We want and it is the intention of this Committee to develop a space station as a permanently manned settlement.

Then why is the life science and medical research necessary to do this being starved in the budget?

I see your brow furrow, Mr. Fisk.

Dr. FISK. Furrow, yes.

Mr. NELSON. Well, where is the money for the Extended Duration Orbiter?

Dr. FISK. Would you like me to answer that now?

Mr. NELSON. Please, go ahead.

Dr. FISK. Fortunately, the Extended Duration Orbiter, the actual implementation of it is not in my budget.

Mr. NELSON. Now that's not an adequate answer.

Dr. FISK. However, what is in our budget and is a strong indication of both our desire to support this activity and the urgency with which we feel that it should be developed, there is $7 million in the life science budget for the specific purpose of developing the medical research activities that need to be conducted in order that an EDO can be safely executed.

And I think that is a measure of the fact that we are aware of the life science issues, the uncertainty of the ability of the Shuttle pilot to be able to land safely and what must be done in advance of that through research and life science to be sure that that landing does occur safely. We do in fact have the resources in the life science budget to be able to do that.

Mr. Nelson. We have got to communicate. We know your problems. We know why the witness yesterday unfairly was beat up upon because he was the messenger, and we said it was unfair, but the Committee had to vent its frustrations.

We will get the appropriate people back here to beat up on. So we are not going to beat up on you and Admiral Truly.

Dr. Fisk. Thank you very much. [Laughter.]

Mr. Nelson. For example, Admiral Truly, in your budget where is the funding for Shuttle-C? Where is the funding for the adequate structural spares for the Orbiter and for the production facility for the Advanced Solid Rocket Motor, and where is that funding for the Extended Duration Orbiter?

So that's the environment in which we start this, we are all friends, we are in the family, but we are going to ask the tough questions.

Now don't do as your colleague did yesterday, even when I told him that I promised this Committee that we are not having witnesses come and read statements, and then he proceeded to go on and read his statement.

Dr. Fisk. All right.

[Dr. Fisk puts his prepared statement aside.]

Mr. Nelson. Good. Talk to us, Dr. Fisk.

STATEMENT OF DR. LENNARD A. FISK, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE SCIENCE AND APPLICATIONS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY SAMUEL KELLER, DEPUTY ASSOCIATE ADMINISTRATOR, OSSA, NASA

Dr. Fisk. Thank you very much. It's a pleasure to be here again.

Let me just comment that I have with me this morning Sam Keller, my Deputy, and Katy Schmoll, the Assistant Associate Administrator for Institutions, Joe Alexander who is an Assistant Associate Administrator for Science and Bob Rome who is an Assistant Associate Administrator for Space Station Activities in Space Science.

I left my Division Chiefs home. They are all hard working. So they are minding the store at the moment.

I have submitted a statement for the record. Let me, if I may, emphasize four points that were in it.

First of all, as you have commented in your opening remarks, we are about to embark on one of the most exciting eras in the history of space science. We not only have Magellan ready for launch essentially two months from today, and Galileo in October and Hubble in December, but we actually have 35 space science missions which are ready to go in the sense that they are under development, they are manifested on either the Shuttle or in ELV, and they will be launched over the next five years.

We have 35 flights scheduled to go over the next five years, and the budget which you have before you supports those activities. And if you look at the history of space science over the entire history of the space program, that is essentially the highest launch rate for space science missions in the history of NASA.

You have to go back into the so-called glory days of the 1960s to find a launch rate which is even slightly higher than that, but at that point of course we were launching relatively simply missions and simple Explorers, and this time we are launching Galileos and Hubbles and gamma ray observatories and upper atmosphere research satellites and TOPEX and so on and so forth.

Basically we will be awash in scientific data, and it is going to be a period of enormous discovery, enormous activity and one which the U.S. leadership in space science will simply not be questioned.

The second point that I would like to emphasize is that we have planned for how to continue that level of activity. This is the Strategic Plan for Space Science and Applications which I think you have all seen because your authorization bill last year bore remarkable resemblance between our plan and what you suggested should be done. That is of course not an accident. We were communicating at that time very well on this plan, and we are doing our best to follow the plan.

The 1989 budget was built around the plan, and the 1990 budget, which you have before you, follows the plan as well, and we have found this a very useful process for being able to balance the needs for major and moderate and small missions, to be able to get ready for a space station, to protect the research base and simply to plan and give direction to our science community as to what order in which we are going to do things so they can plan their careers.

It has been a very useful process and one we are very pleased with the reception the plan received, and we are going to do our best to follow it.

The third point I would like to make is again following off your opening remarks, this is a year of particular significance for planetary exploration. The United States has had a planetary program. We pioneered the field basically back in the 1960's and early 1970's. We were the leaders beyond question.

But in recent years that leadership has been very much in question. The last planetary launch was in 1978 with Pioneer Venus, and the last planetary event was the Voyager encounter with Uranis in 1986 and sort of nobody remembers because it occurred essentially the week of the Challenger accident which dominated the news and concerns at that time.

But we are coming back in planetary this year. We say it's back to the planets this year because we have not only the Magellan launch to Venus and the Galileo launch to Jupiter, but we have a new new-start request in our budget for CRAF-Cassini. CRAF goes to a comet and Cassini goes to Saturn.

Now that mission has great significance for us because it really addresses very fundamental issues of from whence did we come, where was the material in the solar system, what was it made of when the solar system was formed, what was the material which is likely to have given rise to life on the earth, what was that material and what was the chemistry associated with that. Perhaps in the course of the questions we can go into the details of how CRAF-Cassini addresses those issues.

Not only is CRAF-Cassini a very exciting mission in itself, but again it lays out a planetary program for the United States now which is active and exciting and will be respected through the year

2006. I like things to go in a nice, orderly fashion, and I like to be able to say we do this, and then as a result of that, we have taken care of a problem and given ourselves a planetary program which is active and exciting over a long period of time.

If you look at it, Magellan goes to Venus this year, gets there in 1990 and does its exploration at the planet until 1993.

The Mars Observer is launched in 1992, it gets to Mars in 1993 and does its exploration to 1996.

Galileo was launched this year. It takes a long time to get to Jupiter. It gets there in '96 and does its exploration to the year 2000.

CRAF is launched in 1995, it gets to the comet in 2000 and does its exploration to 2002. Cassini is launched in 1996, it gets to Saturn in 2002 and does its exploration to 2006.

So with this new start and these launches this year and the Mars Observer in 1992, we have a planetary program with a mission in its exploration phase returning new data continuously from 1990 to 2006, and I don't think anyone every again will question the U.S. planetary program.

The fourth and final point I would like to make is sort of outside the budget that we are going to be discussing today, but one which I feel quite strongly about. If I look at the principal limiting factor in my being able to execute the Space Science and Applications Program, it is the manpower at NASA Centers. That is the one we have the most difficulty with.

We can ask for and frequently get funded for the correct amount of R&D dollars, but then when we go to administrate that through our NASA Centers and through NASA Headquarters itself, we are limited in our ability to be able to put manpower on those programs to be able to monitor the contracts, to do new technical development and to essentially lead these projects in which the taxpayers and the U.S. Congress is prepared to invest.

I think we have to be very careful as we consider this budget that we make sure that the NASA Center structure is able to support the activities we want to do.

I would be pleased to answer questions.

[The prepared statement of Dr. Fisk together with the fiscal year 1990 budget request follows:]

March 1, 1989
OSSA Testimony FY 1990

Statement of

Dr. Lennard A. Fisk

Associate Administrator for Space Science
and Applications

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science, Space and Technology
House of Representatives

Mr. Chairman, Members of the Subcommittee:

While we have had an active and rewarding year since I last met with you to discuss the OSSA budget, we are about to embark on one of the most exciting eras in the history of the United States Civilian Space Program. During the next five years we have scheduled for launch, i.e., payloads funded, under development, and manifested on either the shuttle or ELVs, some 35 science and applications missions. These five years will essentially match the highest launch rate for science missions in NASA's history. We will witness the flights of Magellan, Hubble Space Telescope, Galileo, the Cosmic Background Explorer, the Gamma Ray Observatory, the Upper Atmospheric Research Satellite and many Spacelabs -- all of which will provide new science data, new science discoveries and new science challenges. Our world leadership in space science will not be in question.

Last year we introduced a strategic plan for the Office of Space Science and Applications which outlined our plan to continue this level of activity well into the next century. The plan balances the need for major, moderate, and small missions. It provides a roadmap for assuring our readiness as major users of the Space Station Freedom. It maintains the research base at U.S. universities and NASA centers which are the key institutional components of the OSSA program. One of the most critical attributes of the plan is that it provides a flexible process for near-term decisions on the allocation of resources and planning for future efforts. I am pleased to say, Mr. Chairman, that this plan has been widely endorsed by the science community as well as various Committees in Congress as a reasonable blueprint for the future of space science and applications in the United States. In fact, your FY 1989 Authorization Bill was the first public acknowledgement and endorsement of the plan, demonstrated by your multiyear authorization language, and for that support we thank you.

I am pleased to say that the FY 1990 budget request that we will discuss today continues to follow the five basic themes which we originally conceived in the strategic plan. First, we continue to provide for the completion of the ongoing program in a timely manner. In April, Magellan will be launched to Venus to survey the planet's surface with radar which penetrates through the Venusian clouds -- the resolution will be an order of magnitude better than any previous U.S. or Soviet mission. Later this year, the Cosmic Background Explorer (COBE), a free-flying Delta-class Explorer, will be launched to measure the cosmic background radiation which is theorized to be a remnant of the primeval explosion, i.e. the Big Bang. In August, Voyager will make its last visit to a planet, Neptune, which has never been explored nor even viewed by mankind at a close distance. Mr. Chairman, just as in the case of Voyager at Jupiter, Saturn, and Uranus, we as a nation and as a global community will marvel at the wonders that Voyager will unveil at Neptune. In October, the long-awaited Galileo mission will be launched on an odyssey to Jupiter where it will send a probe into Jupiter's atmosphere and conduct a two year tour of Jupiter's satellites. And finally, in December, the piece de resistance will be the launch of the Hubble Space Telescope, which will revolutionize our knowledge of astronomy of the universe.

Second, the strategic plan allows us to move boldly forward in a key area of space science to ensure that our world leadership is preserved in the future. Last year we demonstrated our continued leadership in astrophysics by the start of the Advanced X-ray Astrophysics Facility -- AXAF. Our FY 1990 budget request makes a bold statement that the United States will continue its world leadership in the field of solar system exploration. We have requested a new start for the combined Comet Rendezvous Asteroid Flyby (CRAF)-Cassini mission. The expansion of the frontier into the solar system begins with robotic exploration and unmanned planetary exploration -- a field which we pioneered and dominated since the beginning of the space age. In recent years our leadership in this field has been questionable since the last U.S. planetary spacecraft was launched more than a decade ago.

Only Voyager and the smaller Pioneer Venus Orbiter, launched in 1978, remain in operation as planetary probes today. However, this year truly demonstrates U.S. leadership in the field of planetary exploration.

I would like to take this opportunity to briefly describe the CRAF-Cassini mission. CRAF will fly into the outer solar system, orbit a comet and send a penetrator into its nucleus. Cassini will orbit Saturn and send a probe into the murky atmosphere of its satellite Titan. CRAF and Cassini together explore the fundamental question of our origins. First, it is believed that the material that formed the solar system is preserved intact in comets and in the giant outer planets such as Saturn. Second, it is believed that the early Earth did not contain sufficient water or perhaps even sufficient carbon to form life. The hypothesis is that the necessary water and carbon were brought here by comets colliding with the Earth. Finally, the early Earth was a much different place than we know today. The chemistry that gave rise to life in the past, is no longer available for us to study. However, we believe that a chemistry similar to that on the early Earth, cold and slow in its reactions, exists today on Titan, a satellite of Saturn. CRAF-Cassini will study the material from which the solar system formed, the material from which life on Earth formed, and the chemistry which gave rise to that life.

The funding request for CRAF-Cassini is $30 million in FY 1990. The runout cost for the development program is approximately $1.6 billion spread over seven years. This runout fits within a budget for the Office of Space Science and Applications which is relatively constant in constant year dollars, in FY 1990 and beyond.

We are a forward looking nation and we are facing a decision on a perishable opportunity. In a few years the alignment of the planets that gave rise to the Voyager grand tour will change and a trip to Saturn in a reasonable number of years will no longer be viable. Jupiter will have moved too far away. Our launch capability is such that to gain the necessary momentum to reach a comet, a spacecraft must swing by Venus. However, the launch opportunities where Venus and a comet are properly aligned, so that the comet can be reached within a reasonable trip time, are absent in the late 1990's. If CRAF-Cassini is not started now, the planetary launch window will not open again until the turn of the century. With the approval of this 1990 start by the Congress and the President, we will create a planetary exploration program for the United States that is active, exciting, and respected from now into the next century. Let me be more exact. With the approval of CRAF-Cassini this year, the U.S. will have a planetary mission in its prime exploration phase continuously from 1990 to the year 2006. Our European colleagues have recognized the value of this science as well. The Federal Republic of Germany will join us on the CRAF mission, providing the Propulsion Module Subsystem and a scientific instrument. The European Space Agency will provide the Titan Probe for Cassini.

It is important also to prepare ourselves for the major initiatives of the future. Our FY 1990 budget request supports Advanced Technology Development in Earth Science and Applications to prepare for the Earth Observing System instruments which will fly on the Space Station Freedom's polar orbiting platforms and as attached payloads on the manned base. These instrument complements are currently being studied for launches in the mid-to-late 1990s. Mr. Chairman, I believe that the linkage between the Earth Observing System and the growing national concern over the environment is a strong one. It is evident given worldwide emphasis and interest in global change, greenhouse effect, ozone depletion, etc. that there is a clear need to: 1) initiate a balanced program to acquire the measurements we can make now, e.g. Arctic and Antarctic ozone measurements; 2) continue support for the analysis of these measurements, e.g. the research and analysis base; 3) develop new observing capabilities, e.g. the EOS instrument complement; and 4) develop the technology for future Earth system science missions. It is vital that a scientific understanding of the Earth system be obtained on a global scale. These plans are consistent with the efforts outlined in the Committee on Earth Sciences "Our Changing Planet" which accompanied the President's FY 1990 Budget.

As we follow the strategic plan, the Nation should envision 1991 as the year that the United States secures its leadership role in the area of Earth system science. Similarly, as we look to the strategic plan for future Space Science and Applications programs, we will continue to study programs e.g., the Space Infrared Telescope Facility (SIRTF), Solar Probe, Orbiting Solar Laboratory (OSL) and Lunar Orbiter (LO) in order to assure that the United States never relinquishes its stature in these fields of science.

The third theme, providing for new flight opportunities in the near term for small missions, continues through the Small Explorer (SmEX) program which began last year. We are in the process of evaluating the proposals in response to the Announcement of Opportunity which was released last year and anticipate final selection in the spring of this year. This program was well received and supported by the science community. I believe, Mr. Chairman, that several years from now we will be able to point to this initiative as an instrumental step in attracting new, young scientists and engineers into space research. As we look to the future, comparable initiatives in the Earth science disciplines will provide new flight opportunities in the near term and will be a valuable complement to our ever increasing need to better understand the delicate balance of the environment of the planet in which we live.

The fourth theme in our budget proposal allows us to move aggressively, yet sensibly, to build research instruments for the Space Station Freedom and its platforms. It is extremely important that we continue to develop the principal areas of space science and applications from which we will derive the greatest benefits by being on and using the Space Station Freedom. Last year marked a leadership initiative in the area of microgravity science. The FY 1990 budget sets the stage for maintaining our leadership position in several critical program areas while establishing a firm foundation to support future initiatives.

In addition to continued support for microgravity science, the FY 1990 budget marks a leadership initiative in the area of life sciences. Substantial planning and preliminary research must be initiated in FY 1990 for the Extended Duration Orbiter (EDO) Medical Program to ensure pilot proficiency and performance during entry and landing and to ensure crew performance for both normal and emergency egress. Likewise, in FY 1990 phase A/B planning for the Extended Duration Crew Operation (EDCO) project is required for the development and verification of suitable countermeasures to enable the Space Station program's baseline plan for crew cycling. This activity is essential to assure crew productivity and Shuttle fleet efficiency. Although the EDO medical program and EDCO are separate and distinct research and technological programs, they are sequentially supportive and make significant contributions to the initial studies for long term agency requirements for extended piloted exploration missions in the future.

Another key initiative in our FY 1990 Space Station activity is the Space Biology Initiative Definition. The core of the space biology initiative is the equipment and facilities that will support the basic science elements in the space life sciences program during the 1990's. This program will focus upon understanding the mechanisms that have evolved to detect and respond to gravity in living systems, and how adaptation proceeds in the space environment. This research will utilize traditional research methodologies applied in the unique environment of space to study fundamental biological mechanisms in plants and animals. The facilities developed in this program will also provide significant benefits which accommodate the scientific goals of other cooperating agencies, e.g., the National Institutes of Health and the National Science Foundation, and will enable relevant research with broad ground-based applicability.

The Space Biology Initiative for STS/Spacelab and Space Station Freedom payloads and the Space Life Sciences Extended Duration Crew Operations program are clearly defined integrated program elements that are designed to avoid resource duplication. They will provide the first opportunity to perform extended periods of essential and integrated biological and biomedical research since the Skylab era of the early 1970's. We can only speculate as to the immeasurable long term benefits to humankind from this research in areas, e.g., osteoporosis, seed germination, and crop productivity. Based on this type of research, we will better understand life processes and their evolution at Earth gravity. The proposed initiatives in the FY 1990 budget are a natural extension of the major scientific thrusts described in the National Academy of Sciences report, "A Strategy for Space Biology and Medical Science for the 1980's and 1990's" and the strategies promulgated by the NASA Life Sciences Strategic Planning Study Committee in the report "Exploring the Living Universe: A Strategy for Space Life Sciences."

The four elements of our space station Freedom initiative, i.e. the development of microgravity facilities, the development of life science facilities, the development of attached payloads, and the selection and study of Earth observing instrumentation for the Polar Orbiting Platform, constitute a comprehensive plan by the space science and applications program to make full and integrated use of the unique opportunities that the Freedom Station will provide to us.

The final theme of the strategic plan promotes key augmentations to the Research and Analysis base, which is the foundation of our program. Mr. Chairman, as I stated last year, this area is the vital underpinning to our program as the base of support for a vigorous and productive research community. I am pleased to state that the FY 1990 budget allows for a revitalization and rejuvenation of this vital national effort. In preparing the FY 1990 budget, NASA together with the Office of Management and Budget, examined the Research and Analysis and Mission Operations and Data Analysis budget for the next five years and developed an approach which provides for a healthy research base not only in 1990 but during the next five years. This budget provides for the long term health and vitality of our university community. Being a former member of this community, I cannot stress to you enough the importance of this endeavor. We are making significant inroads in encouraging our young people to enter the fields of science, engineering, mathematics, and computer science because there is a future there for them and it is necessary for the health and well being of the country.

In closing, Mr. Chairman, I would like to emphasize one other critical element of the Space Science and Applications Program, namely the NASA Institution, i.e, people, facilities, and resources. We have been assigned the responsibility to provide the United States with a first class civilian space program. To do so, the country must recognize that this requires adequate funding to 1) hire and retain scientists, engineers, and managers to lead our world class science applications programs; 2) develop and build world-class R&D facilities i.e., laboratory buildings; and 3) provide resources i.e., travel funds to adequately manage and/or remain current in a field of expertise. We must ensure adequate support be continued for these activities.

The FY 1990 budget request permits us to complete the ongoing program and to build to the future, the with confidence that we are providing this nation with a space science and applications program that is second to none. In doing so we, along with the entire civilian space program, are making an essential contribution to the national welfare.

Before I briefly describe the specifics of our FY 1990 Budget Request, I would like to mention just three highlights of the past year -- aircraft/spacecraft observations of the Yellowstone Fires; Microgravity Science on STS-26; and the Airborne Arctic Stratospheric Expedition. These serve as examples of the return we have realized on our investment in space science and applications.

HIGHLIGHTS

1. Aircraft and Spacecraft Observations of the Yellowstone Fires

During late summer 1988, Yellowstone National Park was the scene of the largest mobilization of fire fighting forces in the United States. The fires in the park and adjacent areas have dramatically altered the landscape and ecological structure and behavior of a national treasure and stimulated debate about management of fire prone ecosystems.

During the fire, research aircraft based at the Ames Research Center flew multiple missions over the affected areas. These remote sensing aircraft were equipped with thermal infrared sensors and cameras that could "see" through the thick layers of smoke blanketing the park and national forest area. These data were transmitted in real time to the ground based Greater Yellowstone Unified Command. The availability of images of new fires and the advancing fire front yielded information on the size, speed and intensity of the fires which helped fire control officials prioritize their available manpower and equipment. In addition to the images provided by aircraft, the progress of the fires over state-wide areas was followed by images provided by orbiting spacecraft (Landsat).

Present plans call for ground and flight studies to document the damage and recovery of the National Forest and Park ecosystems. These proposed studies, to be jointly undertaken by the National Park Service of the Department of Interior, the Forest Service of the Department of Agriculture, and NASA, will map the extent and severity of burning, examine the success of natural forest regeneration and determine ecosystem effects, e.g. fire-related loss of soil nutrients. These studies should prove invaluable in determining future fire management policies and increasing our understanding of the effect of fires on forest ecosystem behavior.

2. Microgravity Science on STS-26

The 1986 Challenger disaster significantly delayed NASA and the free world's space flight opportunities. However, during 1988, space explorations were resumed along with microgravity science investigations.

Two investigations were flown on the STS-26 mission: the Automatic Directional Solidification Furnaces (ADSF), designed to process four Magnetic Metal Alloy samples by directional solidification in the classic Bridgman mode; and the Protein Crystal Growth (PCG) apparatus, designed to produce larger crystals in order to understand the complex structure of specific protein molecules. The following experiments were also flown aboard STS-26:

1) Isoelectric Focusing in Space (IEF) - A type of electrophoresis experiment which separates proteins in an electrical field; it was specifically designed to distinguish between electro-osmosis and electro-hydrodynamic (EHD) effects by varying the surface to volume ratio of the focusing cells.

2) Phase Partitioning Experiment (PPE) - Was designed to better differentiate the roles of gravity and other forces in separating or partitioning biological substances.

3) Aggregation of Red Blood Cells (ARC) - Was configured to provide information on the formation rate, structure, and organization of red cell clumps, and to investigate the potential beneficial role of microgravity in clinical research and medical diagnostic testing.

Preliminary analysis of the data received from some of these experiments is as follows:

PCG - 60 different experiments in protein crystal growth using the vapor diffusion method were performed on STS-26. Included among these were 11 different proteins, selected because they all display typical crystal growth problems under unit gravity conditions. For example, five droplets of the enzyme reverse transcriptase were flown on this mission. The reverse transcriptase enzyme is specifically responsible for the multiplication -- and therefore spread -- of the AIDS virus. Without this enzyme, it appears that the AIDS virus will not reproduce in the human body. It is therefore critical to understand this enzyme and its structure; Earth-grown crystals have proven totally inadequate. It is expected that space-grown crystals will allow important advances in understanding the enzyme's action and will point the way to the development of drugs much more effective than today's best therapy. While we were unsuccessful in our attempt to grow reverse transcriptase on this flight, results indicated that better purification of the samples would be needed before crystal growth would be possible. We will continue our efforts on future flights. However, initial x-ray diffraction results indicate that the crystals obtained for four of the other proteins flown display a structural order better than crystals of the same materials obtained on Earth.

IEF - Additional evidence to support findings on STS-11 experiments was obtained, indicating that the major source of convective turbulence is due to an electro-hydrodynamic effect, not electro-osmosis. Fluid protein behavior in focusing, although not fully explained, indicated even more turbulent behavior than observed in terrestrial controls. The onset of this turbulence was not synchronized with acceleration surges of the Shuttle.

PPE - The experiment consisted of a transparent module with 18 chambers of two-phase systems, each differing in various physical parameters (e.g., viscosity, volume fraction, and interface potentials). The PPE was configured to study two methods of phase separation (natural coalescence and surface tension) to allow variations in interfacial tension, phase volume ratio, phase system compositions, and added particles. The experiment was repeated three times and analysis of the data is proceeding.

Preliminary science reports are expected to be published in early 1989.

3. Airborne Arctic Stratospheric Expedition, 1989

The Airborne Arctic Stratospheric Expedition was undertaken to examine the chemical and dynamical processes that control ozone in the Arctic winter stratosphere. The overall goal of this mission was to establish whether the processes that contribute to the Antarctic ozone depletion are operative in the Northern Hemisphere.

For six weeks at the start of 1989, NASA and NOAA jointly undertook an Airborne Arctic Stratospheric Expedition to study the nature of potential depletion of stratospheric ozone over the Arctic. Between January 1 and February 15, 1989, specially instrumented NASA ER-2 and DC-8 aircraft flew some 20 missions over the Arctic and to the North Pole, allowing substantial penetration of the Arctic vortex. Flights were timed to coincide with the most active period for the formation of extremely low-temperature polar stratospheric clouds in the area. Such clouds are involved in the complex processes that result in the destruction of stratospheric ozone measured over the Antarctic.

Additional national and international project and scientific support was provided by the National Science Foundation's National Center for Atmospheric Research, the Chemical Manufacturers' Association, Harvard University, the University of

Denver, Pennsylvania State University, the United Kingdom Meteorological Office, the University of Cambridge, U.K., the University of Oslo, Norway, Kernforschungsanlage (KFA) in Julich, FRG, and the Danish Meteorological Institute.

The Arctic Expedition was planned as a follow-on to the Airborne Antarctic Campaign in 1987. Detailed results from that experiment, undertaken to further investigate the Antarctic ozone "hole" first detected by the British Antarctic Survey in 1985, were released in the spring of 1988. Based on those data, a fuller picture of the Antarctic ozone hole has emerged. The findings indicate that:

- o Between August and November 1987, column ozone was at its lowest level ever measured at latitudes below 60 degrees south. Ozone levels fluctuated dramatically over large areas in only a day or so, indicating that meteorology plays a critical role in ozone changes in the Antarctic.

- o The chemical composition of the Antarctic stratosphere is highly perturbed in the Antarctic compared to elsewhere on the planet. There are differences in the distribution of the chlorine species, in the abundance and distribution of the nitrogen species, and chlorine dioxide levels are highly elevated. In addition, the atmosphere is both denitrified and dehydrated.

Detailed understanding of the exact causal mechanisms will require further analysis. The weight of observational evidence does indicate, however, that both chemical and meteorological processes upset the ozone levels in 1987.

A summary of observations and preliminary findings was issued at the end of the Arctic Expedition on February 17, 1989. The initial observations from this mission add up to a consistent picture that is similar to the one drawn from the Antarctic data in 1987 and are believed to be the result of chemical reactions occurring on the Polar Stratospheric clouds (PSC) that form at cold temperatures. The preliminary results of this mission have substantially increased confidence in scientific understanding of the PSC-induced, chlorine data catalyzed, ozone depletion phenomenon. As a result, it is clear that enhancements of chemically active chlorine components do indeed occur in both the Arctic and Antarctic stratosphere.

BUDGET SUMMARY

I would like to now briefly describe the FY 1990 budget request for Space Science and Applications. The detailed budget, with narratives, has already been submitted. A summary is provided on charts 1 through 3. The total FY 1990 request for Research and Development for the Office of Space Science and Applications is $1,995.3 million. This request will provide the critical support needed to continue our recovery from the Challenger accident, and help return our nation to a preeminent position in the world space science community.

We request $894.5 million for Physics and Astronomy. This will provide for development and operations of the Hubble Space Telescope, to be launched in December 1989, and the Gamma Ray Observatory, to be launched in 1990. This budget line also includes Global Geospace Science, a program managed in our Space Physics Division, and the Explorer Program, which will launch the Cosmic Background Explorer later this year. Continuing funding is also requested for the Advanced X-Ray Astrophysics Facility (AXAF), consistent with Congressional direction on this project.

We request $396.9 million for Planetary Exploration. This will provide the funding required to pursue an excellent planetary program. Our efforts at recovery from the Challenger accident will be rewarded with the 1989 launches and subsequent operations of the Magellan and Galileo spacecraft; the Voyager flyby of Neptune this year is also expected to yield exciting scientific data. The request also supports the continuing development of the joint NASA-European Space Agency Ulysses mission, scheduled for a late 1990 launch, as well as the Mars Observer, scheduled for launch in 1992. Initial funding is requested for the dual Comet Rendezvous Asteroid Flyby/Cassini missions, NASA's highest priority new start. CRAF/Cassini offers an excellent science opportunity with strong international participation, at a cost reduced by the use of common elements.

We request $124.2 million for Life Sciences. This funding will support our systematic build-up to the Space Station era, while maintaining our ongoing programs. Included in this budget are funds for: the Extended Duration Orbiter medical program; definition and development of integrated Spacelab payloads for six missions from FY 1990 to FY 1992; establishing Specialized Centers of Research at selected universities; definition and initial development activities for a 1.8 meter centrifuge facility; continuing work on the exobiology microwave observing project; and planning and research to ensure crew health and safety during future extended Shuttle missions and Space Station assignments. As I mentioned earlier, Mr. Chairman, this program has been carefully developed in response to the recommendations of science advisory groups from inside and outside of NASA.

In the Space Applications budget, we request $434.3 million for Earth Science and Applications. This will continue to support the strong progress we have made in studying the individual components of the Earth, including the interior, crust, biosphere, oceans, ice cover, and atmosphere. It will also allow us to undertake important steps toward developing an understanding of the Earth system as a whole. The budget will support a wide ranging research and analysis program in upper atmospherics, oceanic processes, land processes, and atmospheric dynamics, as well as in areas that cut across these disciplines. The request includes funds for continuing development of the Upper Atmosphere Research Satellite, as well as the joint U.S./French Ocean Topography Experiment. Development of the Scatterometer instrument continues in FY 1989. Following cancellation of the Navy Remote Ocean Sensing Satellite (N-ROSS) which was the original flight opportunity for the Scatterometer; NASA has pursued another potential flight opportunity with the Japanese. The Japanese have made a preliminary selection of the Scatterometer for the ADEOS mission. This selection was made so that the Scatterometer could be included in the ongoing ADEOS Phase B study. Final selection will be made in August 1989 concurrent with final mission approval by NASA.

We request $92.7 million for Materials Processing in Space. These funds will provide for continuing microgravity payload missions on STS, as well as for definition and design work on the six currently envisioned microgravity facilities for the Space Station Freedom.

We request $18.6 million for Space Communications and $34.1 million for Information Systems. In Space Communications, we will continue to support the Satellite Aided Search and Rescue (SARSAT) program, Radio Science and Support Studies, Communications Data Analysis and Advanced Communications Research. Our request for Information Systems reflects consolidation of networking requirements within the OSSA information systems program, as well as our commitment to prepare for the six-fold increase to data volume expected in the next five years. No funding is requested in FY 1990 for the Advanced Communications Technology Satellite (ACTS) Program, consistent with the position of the Administration to avoid possible competition with the private sector and to minimize government subsidies for activities more appropriately and effectively undertaken by the private sector.

As a whole, this budget request supports a vigorous and balanced Space Science and Applications program. It will continue the critical support needed to carry out the ongoing program, prepare us for an orderly transition to the Space Station, and establish the strong planning base needed for the program of the future.

CONCLUSION

Mr. Chairman, I believe that this budget request is consistent with the requirements for continued U.S. leadership in space science and applications -- a leadership that we can be proud of and a leadership whose merits will be unquestioned. Let us continue to pursue the wonders of the universe both beyond the bounds and within the confines of this planet.

OFFICE OF SPACE SCIENCE AND APPLICATIONS

FY 1990 BUDGET REQUEST

(DOLLARS IN MILLIONS)

	FY 1988 BUDGET	FY 1989 REQUEST	FY 1989 BUDGET	FY 1990 REQUEST
PHYSICS & ASTRONOMY	**614.4**	**791.6**	**734.1**	**894.5**
HUBBLE SPACE TELESCOPE DEV	93.1	102.2	95.9	67.0
GAMMA RAY OBSERVATORY DEV	53.4	41.9	41.9	26.7
GLOBAL GEOSPACE SCIENCE	18.6	101.4	64.4	112.3
ADV X-RAY ASTROPHYSICS FAC	0.0	27.0	16.0	44.0
SPACELAB PAYLOAD MISSION MGMT & INTEG.	47.8	61.5	69.7	86.1
PAYLOAD & INSTRUMENT DEV	46.6	77.1	81.7	71.4
SPACE STATION PLANNING/ ATTACHED PAYLOADS	18.9	8.0	8.0	23.0
EXPLORER DEVELOPMENT	67.9	82.1	82.1	93.2
MISSION OPS & DATA ANALYSIS	140.5	156.2	143.2	204.8
RESEARCH & ANALYSIS	82.9	89.1	85.8	112.5
SUBORBITAL PROGRAMS	44.7	45.1	45.4	53.5
PLANETARY EXPLORATION	**327.7**	**404.0**	**416.6**	**396.9**
GALILEO DEVELOPMENT	51.9	61.3	73.4	17.4
ULYSSES DEVELOPMENT	7.8	10.3	10.3	14.5
MAGELLAN DEVELOPMENT	73.0	33.9	43.1	0.0
MARS OBSERVER DEV	53.9	102.2	102.2	100.5
MISSION OPS & DATA ANALYSIS	73.8	112.7	110.7	155.4
RESEARCH & ANALYSIS	67.3	83.6	76.9	79.1
CRAF/CASSINI	0.0	0.0	0.0	30.0

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OFFICE OF SPACE SCIENCE AND APPLICATIONS

FY 1990 BUDGET REQUEST

(DOLLARS IN MILLIONS)

	FY 1988 BUDGET	FY 1989 REQUEST	FY 1989 BUDGET	FY 1990 REQUEST
LIFE SCIENCES	72.2	101.7	78.1	124.2
FLIGHT EXPERIMENTS	33.8	54.5		
HUMAN FLT/SYS ENGINEERING			27.6	42.8
SPACE BIOLOGICAL SCIENCES			10.1	27.6
RESEARCH AND ANALYSIS	38.4	47.2	40.4	53.8
SPACE APPLICATIONS				
EARTH SCI & APPLICATIONS	389.2	450.4	413.7	434.3
EARTH SCI PAYLOAD INST. DEV.	27.7	45.0	46.4	66.5
GEODYNAMICS	32.3	33.9	32.9	38.0
LAND PROCESSES R & A	21.1	22.9	19.9	22.5
INTERDISCIPLINARY R & A	1.1	1.2	2.2	2.3
UPPER ATMOSPHERE R & A	32.7	34.0	31.1	38.1
OCEANIC PROCESSES R & A	20.1	21.6	20.8	24.5
ATMOSPHERIC DYNAMICS/ RADIATION R & A	31.4	32.8	32.0	37.4
MISSION OPS & DATA ANALYSIS	14.7	18.5	17.6	24.8
UPPER ATMOSPHERE RES SATELLITE	89.2	103.9	94.2	73.9
SCATTEROMETER	22.6	15.8	10.6	13.8
OCEAN TOPOGRAPHY EXPERIMENT	74.5	97.8	83.0	72.8
AIRBORNE SCIENCE & APPLICATIONS	21.8	23.0	23.0	19.7

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OFFICE OF SPACE SCIENCE AND APPLICATIONS

FY 1990 BUDGET REQUEST

(DOLLARS IN MILLIONS)

	FY 1988 BUDGET	FY 1989 REQUEST	FY 1989 BUDGET	FY 1990 REQUEST
MATERIALS PROCESSING IN SPACE	**62.7**	**73.4**	**75.6**	**92.7**
RESEARCH & ANALYSIS	12.9	13.6	13.6	13.0
MICROGRAVITY PAYLOADS	49.8	59.8	56.4	74.6
COMMERCIAL MICROGRAVITY R & D			5.6	5.1
SPACE COMMUNICATIONS	**94.8**	**16.2**	**92.2**	**18.6**
SEARCH & RESCUE TRANSITION	1.3	1.4	1.4	1.3
RESEARCH & ANALYSIS	17.9	14.8	16.2	17.3
ACTS DEVELOPMENT	75.6	0.0	74.6	0.0
INFORMATION SYSTEMS	**20.8**	**22.3**	**19.9**	**34.1**
TOTAL OSSA	**1,581.8**	**1,859.6**	**1,830.2**	**1,995.3**

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Office of Space Science & Applications

FY 1990
BUDGET REQUEST

National Aeronautics and
Space Administration

NASA FY 1990 BUDGET REQUEST

(DOLLARS IN MILLIONS)

	FY 1988 BUDGET	FY 1989 BUDGET	FY 1990 REQUEST	% Δ FY89-FY90
SPACE STATION	392.3	900.0	2,050.2	128%
SPACE TRANSPORTATION SYSTEMS	3,519.7	4136.9	4676.5	13%
SPACE TRANSPORTATION CAP. DEV.	593.4	618.0	639.0	
SPACE FLIGHT OPERATIONS	2,926.3	3,518.9	4037.5	
SPACE SCIENCE & APPLICATIONS	1,581.8	1,830.2	1,995.3	9%
COMMERCIAL PROGRAMS	48.7	44.7	61.0	37%
TECHNOLOGY UTILIZATION	19.0	16.5	22.7	
COMMERCIAL USE OF SPACE	29.7	28.2	38.3	
AERONAUTICS & SPACE TECHNOLOGY	606.7	769.5	927.9	21%
AERONAUTICAL R & T	332.9	404.2	462.8	
TRANSATMOSPHERIC R & T	52.5	69.4	127.0	
SPACE R & T	221.3	295.9	338.1	
SAFETY, RELIABILITY & QA	14.1	22.4	23.3	4%
TRACKING & DATA ADVANCED SYS	897.3	964.1	1122.0	17%
TRACKING & DATA ADV SYS	17.9	18.8	19.9	
CONTROL & DATA COMMUNICATIONS	879.4	945.3	1,102.1	
CONSTRUCTION OF FACILITIES	178.3	275.1	341.8	25%
RESEARCH & PROGRAM MANAGEMENT	1,762.2	1,891.6	2,032.2	8%
UNIVERSITY SS & T ACADEMIC	(21.6)	(22.3)	35.0	
INSPECTOR GENERAL	(7.1)	(8.6)	8.8	
TOTAL NASA	9,001.1	10,897.5	13,274.0	22%

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NASA'S FY 1990 BUDGET HIGHLIGHTS

(OTHER THAN OFFICE OF SPACE SCIENCE & APPLICATIONS)

(DOLLARS IN MILLIONS)

SPACE STATION FULL FUNDING	INCLUDES $1,970M FOR DEVELOPMENT; $80M FOR DEFINITION, OPERATIONS, FLIGHT TELEROBOTIC SERVICER, AND ORBITAL DEBRIS RADAR. ALSO REQUESTS AUTHORIZATION/ APPROPRIATION OF $2980M (FY 91) AND $3,494M (FY92)	$2,050.0
SHUTTLE FLIGHT RATE/ELV's	PROVIDES FOR NINE FY 90 SHUTTLE LAUNCHES (INCLUDING GALILEO, HST, ASTRO-1, GRO, AND SLS-1), AND FOUR ELV LAUNCHES (INCLUDING ROSAT AND CRRES). CONTINUES FUNDING FOR TWO DELTA II's (ROSAT, EUVE) AND ONE TITAN III (MARS OBSERVER). COMPETITIVE PROCUREMENT OF ELV'S FOR WIND, GEOTAIL, POLAR, & MSAT, AS WELL AS TWO SMALL MISSIONS/YEAR AFTER 1991. INITIATES FUNDING FOR INITIAL INTEGRATION OF ONE TITAN IV (CRAF) AND ONE INTERMEDIATE CLASS ELV (SOHO)	$3,868.0 (STS) $169.0 (ELV)
PATHFINDER	PROVIDES AN INCREASE OF ~$7M OVER FY 89 FUNDS; $10M PROVIDED FOR HUMAN EXPLORATION MISSION DESIGN CASE STUDIES	$47.0
CSTI	PROVIDES AN INCREASE OF ~$23M OVER FY 89 FUNDS, ALMOST ENTIRELY FOR AN AEROASSIST FLIGHT EXPERIMENT (AFE) APPLICABLE TO A FUTURE SPACE TRANSFER VEHICLE (STV)	$144.0

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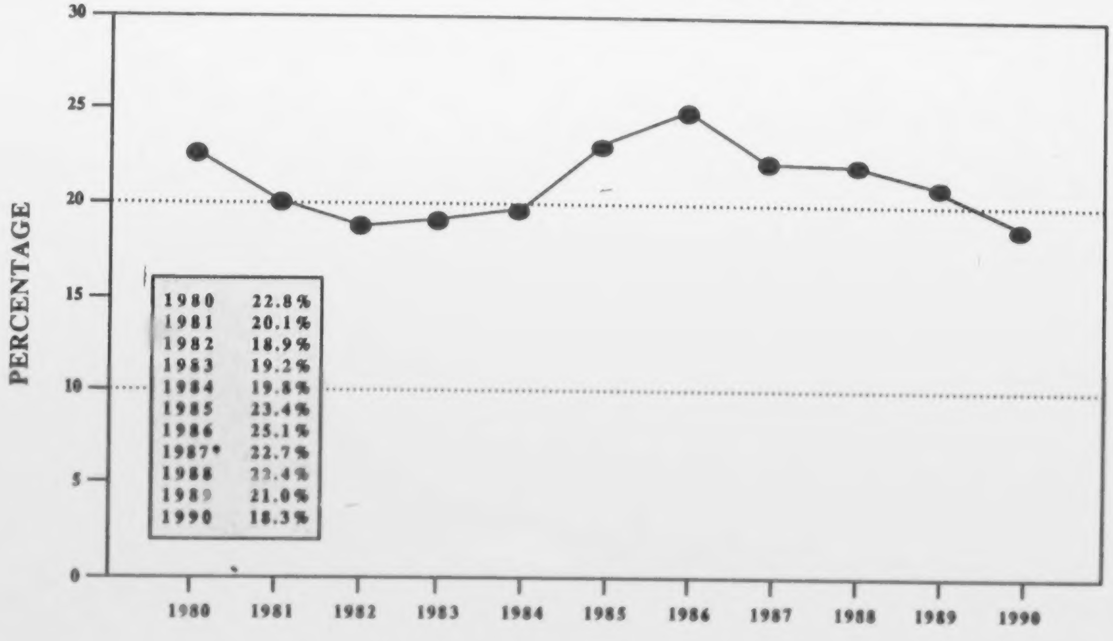
OSSA SHARE OF NASA R&D BUDGET

(R&D AND SFCDC APPROPRIATIONS)



1980	22.8%
1981	20.1%
1982	18.9%
1983	19.2%
1984	19.8%
1985	23.4%
1986	25.1%
1987*	22.7%
1988	22.4%
1989	21.0%
1990	18.3%

* DOES NOT INCLUDE FUNDING FOR 4th ORBITER

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SSA

STRATEGIC PLAN

OFFICE OF SPACE SCIENCE AND APPLICATIONS

PROGRAM THEMES

- COMPLETE THE ON-GOING PROGRAM IN A TIMELY MANNER
- MOVE BOLDLY IN KEY AREAS OF SPACE SCIENCE AND APPLICATIONS TO PROVIDE WORLD LEADERSHIP IN SPACE EXPLORATION
- PROVIDE NEW FLIGHT OPPORTUNITIES IN THE NEAR TERM WITH SMALL MISSIONS
- MOVE AGGRESSIVELY BUT SENSIBLY TO BUILD SCIENCE INSTRUMENTS FOR THE SPACE STATION AND ITS PLATFORMS
- ENSURE A VITAL AND PRODUCTIVE RESEARCH BASE

OFFICE OF SPACE SCIENCE AND APPLICATIONS

STRATEGIC PLAN

YEAR	ONGOING PROGRAM	MAJOR & MODERATE MISSIONS	SMALL MISSIONS	SPACE STATION UTILIZATION	RESEARCH BASE ENHANCEMENTS
1989	RESEARCH AND ANALYSIS	AXAF	SCOUT-CLASS EXPLORERS	MICROGRAVITY FAC 1.8m CENTRIFUGE ATTACHED PAYLOADS EOS PAYLOAD DEFN	SETI MOP CRAF/CASSINI ATD SN 1987A SUB-ORB. OBS ER-2 PURCHASE
1990	MISSION OPERATIONS & DATA ANALYSIS FLIGHT PROJECTS	CRAF/CASSINI		SPACE BIOLOGY INITIATIVE DEFINITION EDO EDCO DEFINITION EOS ATD SPACE STATION ATTACHED PAYLOADS & PLANNING	SOUNDING ROCKETS & BALLOON PROGRAMS SPACE PHYSICS R&A PLANETARY R&A LIFE SCIENCE R&A MO & DA SCIENCE DATA MGMT
1991 THROUGH 1995	SPACELABS & OTHER CARRIERS	EOS OSL SIRTF LO SOLAR PROBE	EARTH PROBES LIFESAT FUNDAMENTAL MICROGRAVITY SCIENCE	SPACE BIOLOGY FACILITIES SECOND-GENERATION ATTACHED PAYLOADS	SOFIA OTHER FOCUSED ITEMS TO ADDRESS SPECIFIC NEEDS

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OFFICE OF SPACE SCIENCE AND APPLICATIONS

FY 1989 KEY OSSA INITIATIVES

- AXAF
  - AXAF PROCEEDING AS A FY 1989 PHASED NEW START
  - MIRROR DEVELOPMENT PROGRESSING ON SCHEDULE
  - INSTRUMENT DEVELOPMENT FUNDING IN 1990 BUDGET
- SMALL EXPLORERS (SMEX)
  - FY 1989 APPROPRIATION FULLY FUNDED SMALL EXPLORER PROGRAM
- MICROGRAVITY FACILITIES
  - FY 1989 APPROPRIATION INCLUDED FUNDS FOR SPACE STATION INITIATIVE
  - FY 1990 BUDGET REQUEST INCLUDED A SMALL REPRICING OF USML HARDWARE
- 1.8M CENTRIFUGE
  - DEVELOPMENT INITIATED — SLOW START
- SETI
  - DEVELOPMENT INITIATED — SLOW START
- ER-2 PURCHASE
  - PURCHASE COMPLETE IN FY 1989

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SSA

COMPLETE
ON-GOING PROGRAM

OFFICE OF SPACE SCIENCE AND APPLICATIONS

PROGRAM THEMES

COMPLETE THE ON-GOING PROGRAM IN A TIMELY MANNER

- INCREASE FOR ON-GOING PROGRAM **+ 63.5**
- FY 1990 BUDGET CHANGES

	FY 1989 BUDGET	FY 1990		
		BASELINE	REQUEST	CHANGE
REPRICING/REPHASING				
GALILEO	73.4	14.4	17.4	3.0
ULYSSES	10.3	9.2	14.5	5.3
COLLAB. SOLAR TERR. RES. (COSTR)	43.9	51.8	54.8	3.0
TSS	7.7	4.2	6.2	2.0
AXAF REPHASING	16.0	70.8	55.0	(15.8)
TOPEX REPHASING	83.0	67.8	72.8	5.0
MARS OBSERVER REPHASING	102.2	87.6	100.5	12.9
MANIFEST CHANGES				
SHUTTLE ATTACHED PAYLOADS	134.5	144.4	173.0	28.6
HST	194.2	181.4	201.4	20.0
GRO	41.9	35.8	37.8	2.0
OTHER				
TERMINATE ACTS	74.6			
VOYAGER INTERSTELLAR			15.0	15.0
COMPUTER COMM. FOR SCIENCE			7.5	7.5
TERMINATE STORE	17.9	25.0		(25.0)

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OFFICE OF SPACE SCIENCE AND APPLICATIONS

ON-GOING PROGRAM REPRICING/REPHASINGS

(DOLLARS IN MILLIONS)

GALILEO	($+3.0)	– ENGINEERING CHANGES TO ACCOMMODATE VEEGA TRAJECTORY – MISSION OPERATION SYSTEM DEFERRED INTO FY 1990 – SHORT-TERM LAUNCH DELAY RE-ESTIMATE
ULYSSES	($+5.3)	– SPACECRAFT INTEGRATION SUPPORT & MISSION OPERATIONS ENGINEERING RE-ESTIMATE
COSTR	($+3.0)	– COMPLEXITY OF SELECTED INSTRUMENTATION
TSS	($+2.0)	– MARTIN MARIETTA INTEGRATION COST GROWTH
AXAF	($-15.8)	– CONGRESSIONALLY DIRECTED REPHASING
TOPEX	($+5.0)	– RESTORATION OF FUNDS TRANSFERRED TO NSCAT IN FY 89
MARS OBSERVER	($+12.9)	– REBASELINE TO MATCH SCOPE, SCHEDULE AND BUDGET

MAJOR EVENTS
SPACE SCIENCE AND APPLICATIONS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1989	ARCTIC OZONE AIRCRAFT CAMPAIGN △△△△△△△△△△			MAGELLAN □		COBE ○		VOYAGER II AT NEPTUNE △		GALILEO □		HST □
1990		○ ROSAT	ASTRO-1/ BBXRT □	GRO □		SLS-1 □ ○ CRRES				ULYSSES □		
1991	TSS-1 □	IML-1 □			ATLAS-1 □		S/L-J □	○ EUVE		UARS □	WAMDII □	S/L-D2 □ ○ SMALL EXPL-1
1992		△ ULYSSES JUPITER ENCOUNTER	USML-1 □	SRL-1 □ ACTS □ USMP-1 □		TOPEX/ POSEIDON ○ ATLAS-2 □ SMALL EXPL-2 ○	GEOTAIL ○ SLS-2 □	ASTRO-2 □	SHEAL-2 □ MARS OBSERVER ○	IML-2 □		SMALL EXPL-3 ○ WIND ○
1993		SRL 2 □	USMP-2 □		ATLAS-3 □	POLAR ○ SMALL EXPL-4 ○		USML-2 □	USMP-3 □	SLS-3 □		SMALL EXPL-5 ○

□ STS LAUNCHES ○ ELV LAUNCHES △ OTHER MAJOR EVENTS

OSSA

LEADERSHIP
IN SPACE SCIENCE

OFFICE OF SPACE SCIENCE AND APPLICATIONS

PROGRAM THEMES

MOVE BOLDLY IN KEY AREAS OF SPACE SCIENCE AND APPLICATIONS TO PROVIDE WORLD LEADERSHIP IN SPACE EXPLORATION

- NEW START FOR CRAF/CASSINI
  - CRAF (COMET RENDEZVOUS ASTEROID FLYBY)
    - 1995 LAUNCH
    - 1998 ASTEROID FLYBY
    - 2000 COMET RENDEZVOUS (KOPFF)
  - CASSINI (SATURN ORBITER/TITAN PROBE)
    - 1996 LAUNCH
    - 2002 ARRIVE AT SATURN
- FY 1990 BUDGET INCLUDES $30.0 MILLION
- CRAF/CASSINI TOTAL DEVELOPMENT COST EQUALS $1.6 BILLION

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CRAF/CASSINI

- CRAF
  - FIRST LONG-TERM STUDY OF COMET, ITS NUCLEUS, AND THE NATURE AND BEHAVIOR OF ITS ATMOSPHERE
  - DIRECT ANALYSIS OF BEST-PRESERVED PRIMORDIAL SOLAR SYSTEM MATERIAL, POSSIBLY INCLUDING INTERSTELLAR MATERIAL
  - ASSESSMENT OF ORGANIC MOLECULES PRESENT AT BEGINNING OF SOLAR SYSTEM AND THEIR CONTRIBUTIONS TO ORIGIN OF LIFE
- CASSINI
  - FIRST LONG-TERM ORBITAL STUDY OF SATURN (ARRIVE 2002) AND DIRECT ANALYSIS OF THICK ATMOSPHERE OF ITS LARGEST MOON, TITAN
  - EXTENDS DETAILED EXPLORATION PHASE PAST JUPITER INTO OUTER SOLAR SYSTEM
  - INTENSIVE, LONG-TERM OBSERVATION OF SATURN'S ATMOSPHERE, MAGNETIC FIELD, MOONS, RINGS
  - DETERMINES PHYSICS, CHEMISTRY, AND ORGANIC CHEMICALS OF TITAN'S ATMOSPHERE, A POSSIBLE MODEL FOR PRIMORDIAL ATMOSPHERE OF EARTH

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COMET RENDEZVOUS ASTEROID FLYBY & CASSINI MISSIONS

(DOLLARS IN MILLIONS)

	1990	1991	1992	BTC	TOTAL
SPACECRAFT DEV.	19.8	109.9	221.2	698.7	**1,049.6**
EXPERIMENTS	8.1	33.5	81.5	301.1	**424.2**
GROUND OPERATIONS	2.1	4.6	10.3	108.2	**125.2**
TOTAL	**30.0**	**148.0**	**313.0**	**1,108.0**	**1,599.0**

KEY FEATURES:

- CRAF TITAN IV/CENTAUR LAUNCH AUGUST 1995
- CASSINI TITAN IV/CENTAUR LAUNCH APRIL 1996
- DETAILED EXAMINATION OF COMET KOPFF FOR 959 DAYS
- DETAILED EXAMINATION OF SATURN SYSTEM FOR FOUR YEARS
- BOTH CRAF & CASSINI ASTEROID FLYBYS EN ROUTE
- ESA TO PROVIDE CASSINI TITAN PROBE AND ESA MEMBER COUNTRY CASSINI SCIENCE INSTRUMENTS
- FEDERAL REPUBLIC OF GERMANY WILL PROVIDE CRAF PROPULSION MODULE AND A SCIENCE INSTRUMENT
- FIRST TWO OF A SERIES OF MARINER MARK II MISSIONS

SMALL MISSIONS

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PROVIDE NEW FLIGHT OPPORTUNITIES IN THE NEAR TERM WITH SMALL MISSIONS

- SCOUT CLASS MISSIONS WERE ADDED TO THE FY 1989 BUDGET TO SUPPORT ASTROPHYSICS, SPACE PHYSICS, AND UPPER ATMOSPHERIC SCIENCE MISSIONS
- EARTH PROBES PROGRAM HAS HIGHEST PRIORITY FOR NEXT SMALL MISSIONS INITIATIVE
  - BUDGET CONSTRAINTS DID NOT PERMIT A 1990 NEW START
  - PHASE B STUDIES WILL CONTINUE FOR CANDIDATE EARTH PROBE MISSIONS

EP-0015-CSB

SPACE STATION

LIFE SCIENCES
IMPACT OF FY 1989 CONGRESSIONAL REDUCTION

- ORIGINAL PLAN
  - INITIATE CENTRIFUGE FY 1989
  - PLAN FOR EXTENDED DURATION CREW OPERATIONS (EDCO) IN FY 1989
  - PLAN SPACE BIOLOGY INITIATIVE (SBI) SPACE STATION

- CONGRESS SIGNIFICANTLY CUT FY 1989 BUDGET BY $25M

- CONSEQUENCES
  - ELIMINATES SLS-1 RESERVES
  - DELAYS DEVELOPMENT OF CENTRIFUGE
  - DEFERS EDCO ACTIVITIES TO FY 1990
  - SLOWS SBI PLANNING
  - DEFERS INITIATION OF SBI UNTIL 1991

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EXTENDED DURATION ORBITER (EDO) MEDICAL PROGRAM

PURPOSE

- TO ENSURE PILOT PROFICIENCY AND PERFORMANCE DURING ENTRY AND LANDING
- TO ENSURE CREW PERFORMANCE IN NOMINAL AND CONTINGENCY EGRESS

STATUS

- STARTING IN FY 1989, NASA WILL EMBARK UPON A THREE YEAR PROGRAM OF GROUND AND FLIGHT INVESTIGATIONS TO PROVIDE SPECIFIC RECOMMENDATIONS, PROTOCOLS AND COUNTERMEASURES TO ENSURE CREW HEALTH AND SAFETY ON EDO MISSIONS OF 16 TO 28 DAYS
- OSSA WILL PROVIDE SCIENCE AND MEDICAL CAPABILITY; OSF WILL PROVIDE FLIGHT RESOURCES OF CREW TIME AND ACCESS TO FLIGHT
- EDO INVESTIGATIONS PROVIDE IMPORTANT INFORMATION ON ESTABLISHING EXTENDED DURATION CREW OPERATIONS (EDCO) ON THE SPACE STATION

FY 1990$ **7.4M**

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SPACE BIOLOGY INITIATIVE (SBI)
DEFINITION

PURPOSE

- NEED TO BUILD STATE-OF-THE-ART FACILITIES AND INSTRUMENTS TO CONDUCT FUNDAMENTAL RESEARCH IN SPACE IN GRAVITATIONAL BIOLOGY AND EXOBIOLOGY
- WELL EQUIPPED SPACE STATION FACILITIES ARE CRITICAL TO LIFE SCIENCES RESEARCH
- SBI FACILITIES AND INSTRUMENTS WOULD BE USED ON SPACELABS PRIOR TO DEPLOYMENT ON SPACE STATION TO SUPPORT SPACELAB SCIENCE PROGRAM (7 – 30 DAY MISSIONS), DEVELOPMENT OF SCIENCE INFRASTRUCTURE AND VERIFICATION OF HARDWARE

STATUS

- DRAFT SCIENCE REQUIREMENTS IN HAND; DEFINITION OF LEVEL/SCIENCE REQUIREMENTS FINALIZED FY 1989 – 1990
- FLIGHT OF SBI FACILITIES ON SPACELABS WILL BE DRIVEN BY SCIENCE REQUIREMENTS AND HARDWARE AVAILABILITY FOR TESTING

FY 1990 $ ***9.0M***

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PROPOSED SPACE BIOLOGY FACILITIES

FACILITIES

BIOLOGICAL SAMPLE MANAGEMENT USED TO COLLECT, STORE AND RETURN BIOLOGICAL SAMPLES

BIOINSTRUMENTATION AND PHYSIOLOGICAL MONITORING TEST INTACT ORGANISMS

ANALYTICAL INSTRUMENTS ANALYZE BIOLOGICAL SAMPLES

LAB SUPPORT EQUIPMENT MONITOR AND MAINTAIN CLEANLINESS OF LAB AND PERSONNEL

CENTRALIZED LIFE SCIENCES TIMESHARED COMPUTER USED TO CONTROL EXPERIMENTS

BIOREGENERATIVE LIFE SUPPORT SYSTEM TEST STUDY FLIGHT FACTORS AND FOOD PRODUCTION

EXOBIOLOGY CONDUCT GAS/GRAIN STIMULATION STUDIES

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EXTENDED DURATION CREW OPERATIONS

PURPOSE

- EXTEND CREW TIME ON SPACE STATION
  - REQUIRED TO REDUCE YEARLY SHUTTLE FLIGHTS NEEDED TO SUPPORT SPACE STATION FROM 8 TO POTENTIAL 4-5
  - ALLOWS MORE EFFECTIVE USE OF HUMAN RESOURCES BY DEVELOPING COUNTERMEASURES TO PROTECT CREW HEALTH AND PRODUCTIVITY THAT MINIMIZE IMPACT ON CREW WORK TIME

STATUS

- BASIC PROJECT ELEMENTS DEFINED
- PROJECT INITIATION AGREEMENT APPROVED
- PROJECT PLAN FOR PHASES A & B BEING DRAFTED
- SPACE STATION RESOURCE REQUIREMENTS ESTIMATED
- REDUCED FUNDING IN FY 1989 REQUIRES DEFFERAL OF EDCO ACTIVITIES TO FY 1990

FY 1990 $ **3.0M**

EP-0189-CSB

SSA

RESEARCH
INITIATIVES

EP-0033-CSB

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RESEARCH INITIATIVES AUGMENTATIONS

- SYSTEMATICALLY REVIEWED ALL RESEARCH AND ANALYSIS, MISSION OPERATIONS & DATA ANALYSIS, AND SUBORBITAL FUNDING NEEDED TO PROVIDE AN ADEQUATE RESEARCH BASE

- CHANGES ARE DESIGNED TO BE A PERMANENT FIX TO THE RESEARCH AND ANALYSIS FUNDING PROBLEMS. OMB HAS AGREED TO THIS FIX FOR THE NEXT FIVE YEARS

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RESEARCH & ANALYSIS AUGMENTATIONS/FIXES

(DOLLARS IN MILLIONS)

	FY 90	FY 91	FY 92	FY 93	FY 94
SPACE PHYSICS SUBORBITAL	+6.5	+6.5	+6.5	+6.5	+6.8
SPACE PHYSICS R & A	+2.0	+3.2	+3.4	+3.6	+3.8
OSL ATD	+5.3				
PLANETARY – INSTR. UPGRADES	+3.0	+3.2	+3.4	+3.6	+3.8
PLANETARY – ORIGINS OF SOLAR SYS.	+2.0	+3.0	+4.5	+6.0	+6.4
LIFE SCIENCES – R & A WITH SCOR	+3.0	+5.0	+8.0	+8.5	+9.0
SETI REPHASING	-4.8	-2.1	+1.7	+1.4	
AIRBORNE – ASTROPHYSICS	+2.4	+2.8	+2.7	+2.8	+2.8

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MO & DA AUGMENTATIONS/FIXES

(DOLLARS IN MILLIONS)

	FY 90	FY 91	FY 92	FY 93	FY 94
ASTROPHYSICS		+11.4	+5.0	+10.9	+5.7
EARTH SCIENCE	+2.5	+6.4	+8.3	+10.6	+11.2
PLANETARY	+15.0*	+17.7	+12.5	+23.0	+24.9
VOYAGER INTERSTELLAR*	+15.0	+16.3	+11.5	+12.1	+12.8
MAGELLAN				+5.4	+5.7
ULYSSES		+1.4	+1.0	+.5	
VOYAGER NEPTUNE				+6.0	+6.4
SCIENCE DATA MGMT & ARCHIVAL	+3.0	+4.1	+4.7	+5.0	+5.4

*IDENTIFIED WITH ON-GOING REPRICINGS

OFFICE OF SPACE SCIENCE AND APPLICATIONS

FY 1990 BUDGET REQUEST

(DOLLARS IN MILLIONS)

	FY 1990 BUDGET
FY 1989 PRESIDENT'S BUDGET	**1870.0**
TRANSFERS EXTERNAL TO OSSA	-6.1
ADJUSTMENTS TO ON-GOING PROGRAM	+63.5
LEADERSHIP INITIATIVE	+30.0
BUILDING TO SPACE STATION	+13.0
RESEARCH INITIATIVES	+19.4
MISSION OPS & DATA ANALYSIS	+5.5
OSSA TOTAL	**1,995.3**

EP-0034-CSB

Mr. NELSON. Mr. Rohrabacher.

Mr. ROHRABACHER. I'm fine.

Mr. NELSON. Mr. Smith.

Mr. Robert Smith of New Hampshire: I'm going to hold off a minute to two.

Mr. NELSON. Mr. Packard.

Mr. PACKARD. Are we standing in line during the next five years for launch services? Are we holding up launches of equipment that will be ready before we will be able to schedule a launch?

Dr. FISK. It's a combination of several things. I mean the Shuttle will fly at a certain flight rate, and we have for science approximately 80 percent of all the non-DOD launches. So in fact science will dominate the Shuttle manifest over the next 5 years.

We also have a number of missions that will be launched on expendable launch vehicles, and in fact basically any mission that could readily be put on an ELV is now on an ELV. Missions like Galileo and like Hubble and like Magellan are designed for the Shuttle, and the cost impact of putting them on ELV's at this time is simply prohibitive.

However, by the time you get to Mars Observer in 1992, which is a mission that was in the process of being designed, we were able to configure that appropriately for an ELV, and at that point in time what goes on the Shuttle is primarily those which require humans or some technical reason to be on the Shuttle, and that which belongs in an ELV goes on an ELV.

Essentially the program is now nicely in sync. Our budgets and our development schedules are all compatible with the Shuttle flight rate and the availability of ELV's and the missions that can be put on ELV's.

So I think we have everything lined up now. To do anything earlier would either be an unrealistic flight rate for the Shuttle, the availability of ELV's that might not exist or budgets that we don't have. Everything is lined up as it should be.

Mr. PACKARD. So in your judgment you feel that we have made some of the transition that we talked about after the Challenger accident of going to more and more of a balanced fleet between the ELV's and the Shuttle?

Dr. FISK. Absolutely. I feel very comfortable at the moment with what we have on the Shuttle. Every payload that I would like on an ELV is now on an ELV, and our budgets and the manifests and our development schedules are all compatible.

Mr. PACKARD. Thank you, Mr. Chairman.

Mr. NELSON. Tell us about ACTS. We have spent $338 million on ACTS and there is about $110 million to complete the program. What do you think Congress should do about it? [Laughter.]

Dr. FISK. Oh, I think Congress should use its best judgment as to how to deal with this program. [Laughter.]

I always feel very secure about ACTS. We continue to build it. We are operating of course under the cap that was agreed on last year and the program is nicely under development. It is a political issue and it has been one for a long period of time. We did request it in our request to OMB.

Mr. NELSON. Why is it that OMB keeps cutting it out when you request it?

Dr. Fisk. They, I feel, are somewhat reluctant to speak for OMB, but it is my understanding that this is an issue in which it is their belief that this type of research should be funded by the private sector and that it is not a proper role for the Government to be involved in this.

Mr. Nelson. Do you think it could? The private sector has put in about $100 million already. There is about $110 million to go. Do you think we could get that out of the private sector?

Dr. Fisk. We could ask. Let me answer it this way. To date no one has come to my office offering funds.

Mr. Nelson. Well, as usual, we don't get any help from NASA on this issue and it happens every year.

Dr. Fisk. We are looking into one of the things that we are anxious to do with this project, which is to be able to make effective use of it once it's up, and we are having discussions with the private sector about their ability to bring forth their resources to essentially help us experiment with ACTS when it is in orbit so that we can make the transition of the technology to the private sector as readily as possible.

As an ongoing activity NASA did form recently what is basically an experimenter's group if you were talking about the equivalent within the normal science program where we put together a group of potential users and we are discussing with them how we can most effectively make this transition once it is launched and operated.

Mr. Nelson. Let me ask you about the ground terminals. In what is scheduled to be spent, are the ground terminals included within that money?

Dr. Fisk. In the $499 million cap one prototype experiment ground terminal is included, but there are no experimental field terminals. That is the issue which we are currently discussing with potential users as to how they might like to come and participate with us in this.

Mr. Nelson. So no experimenter field terminal.

Dr. Fisk. That's correct.

Mr. Nelson. How many of those do you expect?

Dr. Fisk. I can't give you an answer to that at this time. The discussions are ongoing with this group as to how they might come and join us on this project. Clearly we would like as many as possible.

We would also like to play with it ourselves. We have our own science data, and it would be principally a demonstration of the technology to ship some of our science data around in using ACTS.

My own feeling is that if we were to make effective use of this thing, that somewhere in the 10 to 15 and perhaps 20 terminal range would be the appropriate number to be able to demonstrate this kind of technology.

Mr. Nelson. All right. In your answer that you don't know how many experimenter field terminals that you expect, when will you know?

Dr. Fisk. I think on the schedule we are currently operating it would be approximately this summer.

Mr. Nelson. Approximately this summer.

Dr. Fisk. Right.

Mr. NELSON. That could be fall and it could be winter.

Dr. FISK. But it shouldn't be spring. [Laughter.]

Mr. NELSON. That's close enough for government work. [Laughter.]

Committee members?

Mr. Packard.

Mr. PACKARD. I would like to follow up briefly on your questions, Mr. Chairman.

Have we considered removing some of the impediments or introducing incentives for the private sector to do some of the things that we can't afford to do at the government sector such as ACTS, or are we just hoping that they will come in and pick up where we leave off or where we can't continue?

Dr. FISK. That is certainly not my intention. I mean one of the reasons that we have formed this group and we are having this discussion is basically to get input from the user community, the communications satellite industry and the ground users as to how we could effectively make this transition.

My history on ACTS is undoubtedly less knowledgeable than the Committee's because you have lived with this longer than I, but ACTS in its sort of on again/off again lifetime here managed to discourage some of the people who originally proposed this mission as something the government should in fact do, and we are making a very active effort now that we are anticipating launching this in May of 1992 to recapture that group and have them come and work with us as to how best to make this technology transfer.

It was my sense when I took over in 1987 that with the difficulties of having this program funded and the slips that occurred as a result of the Challenger accident that some of the original group that wanted this program and promoted it had gotten discouraged and were off doing other things, and we are attempting now to recapture that group in the most effective way we can simply to ask them what can we do best to make this work on their behalf.

Mr. PACKARD. That's all, Mr. Chairman.

Mr. NELSON. Dr. Fisk, we had an agreement with NASA two years ago over our objection when they slipped Mars Observer from 1990 to 1992. In the final agreement, which we had to accept—you—NASA dragged your feet until it was too late. So you won. But what we got in the agreement was that there would be an observer, a follow-on Observer to the Mars Observer, but that wasn't in your request to OMB. Why?

Dr. FISK. It's simply early for the follow-on Observer. The intention, as you will recall, is that we will through the spare policy that is being used on Mars Observer, that we will turn those spares into the follow-on Observer. Now the Mars Observer was launched in 1992 and therefore the spares become available essentially at that time, and in our Strategic Plan we call out for a moderate mission, which is how we call it. The one that is in the plan at the moment is Lunar Orbiter, which would be the logical mission to use the Mars Observer spares.

Mr. NELSON. For 1994?

Dr. FISK. You could make a '94 launch, that is correct. Now there is an active discussion, however, as to whether or not as we begin to develop our Mars program, to look at Mars, whether we look at it as a U.S. alone initiative or we look at it in some connection with the Soviets, and whether or not it would be more appropriate to have a follow-on Mars mission as opposed to a follow-on Lunar mission, and in that case you would probably use the '96 launch opportunity for Mars as opposed to the '94 launch opportunity. The spares could be just as easily directed towards that program as towards a Lunar program. Those decisions should hopefully be made this year at sometime.

Mr. NELSON. What the agreement was is that you would have an Observer line item, not what you just described. So where is it?

Dr. FISK. It is not there. There are a number of disadvantages, in my judgment, to an Observer line item associated with a planetary mission, one of which is that in the case of Observers, if you follow the Explorer model, the principal variable that you have in Explorer is schedule. You are fixed in a funding profile, and the funding profile is one that is agreed upon, and if you run into technical difficulties, then you adjust your schedule to fit within the same profile.

For example, in the case of COBE, which is now coming to launch, we are encountering small difficulties at the end, nothing large, but the impact of that is on EUVE, which is the downstream issue, and its launch date is adjusted to fit whenever we deliver COBE.

Planetary missions, on the other hand, have fixed windows, and you cannot make the adjustment in the schedule in the same sense that you do in the Explorer Program, and the Mars Observer is an example of that, although with the 1992 slip, when we went to 1992, you will recall that last year we still continued to encounter funding difficulties with the Mars Observer. We descoped one of the instruments off the mission to bring it back into the originally agreed upon cost, but the cost was not properly phased in order to make a 1992 mission.

And in the budget submission you have before you we did the rephasing of the program bringing money into the 1990 budget and removing it from the 1991 and 1992 budget in order that we remained on the 1992 launch schedule. Under a normal Observer fixed program as in the case of the Explorer model, that would not have been possible and the Mars Observer would now be 1994, which of course would be unacceptable to all of us.

So I think there are some advantages to running the planetary missions as single new starts under those rules, but I think we have the best of both worlds in this. We have a very aggressive spares policy which allows us then to feed naturally into the follow on mission and have a continuous Observer program, but not in a continuous Observer line.

Mr. NELSON. Is what you just said the recommendation of the science community?

Dr. FISK. The science community does not always get into management issues, but I think if the science community understood the management issue that they would agree on that.

Mr. NELSON. The science community also understood that a deal was a deal and that you were to have a line item on this Observer, and that all that talk about planetary windows and so forth, that if you go to the Lunar Orbiter you don't have to have a planetary window.

Dr. **Fisk**. That's fair, but a follow-on Mars does.

Mr. **Nelson**. We would like to see a little more aggressive forthcoming with regard to the agreement that we struck.

Now we had some harsh words over the fact that you all delayed that Mars Observer from 1990 to 1992, and when we finally walked away from that issue we thought we had a very clear understanding. You know, if you keep jilting your lover, pretty soon the lover is going to walk away.

Dr. **Fisk**. I would not like that to happen.

Mr. **Nelson**. I would not like that to happen either.

Members of the Committee? [No response.]

I want to ask you about the runout. You had a runout for over three years, and the runout keeps increasing. You had a total figure of just under $2 billion for 1991, $2.1 billion for 1992 and $2.355 billion. So you've got increases in our science budget over the next three years, but you don't have any new starts.

Dr. **Fisk**. Well, of course included in the 1990 budget is the new start for CRAF-Cassini. If you look at that budget, with the exception of 1992, that budget increases only at inflation. So those increases are basically inflationary increases, with the exception of 1992, and if you average over the five-years, it does not increase any more than inflation. So basically the Space Science and Applications budget as proposed in the 1990 budget is constant in constant year dollars over the next five years.

It would be my anticipation that in the 1991 budget we would follow our Strategic Plan, which has an identified new start request in 1991 as well as requests for the space station, our small mission options and our research base enhancements, and that that would be the basis for the 1991 budget submission.

Mr. **Nelson**. What about a multiyear request that fits with your Strategic Plan?

Dr. **Fisk**. How would you like me to answer that? I mean we have a very clear understanding of what we would like to do year by year. There is no uncertainty in my mind about the fact that we can specify both this year and in subsequent years what it is the programs should in fact consist of.

Mr. **Nelson**. Well, that's supposed to be what NASA is supposed to be coming to us with a request for authorization for two years with a third year as a target. That has not been the case. That, however, happens to be the law. Can you get in there and change it?

Dr. **Fisk**. Can I get in and change the law or NASA? [Laughter.]

Mr. **Nelson**. Can you get in there and change NASA to comply with the law?

Dr. **Fisk**. I will communicate to the man who heads NASA that that's the law.

Mr. **Nelson**. We did communicate that to him, but it didn't seem to sink in. I wish you would communicate that as well.

Dr. **Fisk**. Okay.

Mr. **Nelson**. Mrs. Morella.

Mrs. **Morella**. Thank you, Mr. Chairman.

I would like to get on another subject, and that is we can put all the money into this program that you feel you need, but how about the personnel? I have been talking to people at NASA, and I also am on the Post Office Civil Service Committee, as you probably know, and if we cannot hire the people that you need on the top levels, on all levels, but especially the top levels, where is the program going? Can you tell me whether in fact you have experienced difficulties with recruiting and retaining and what you feel you can do about it and what you feel we must do about it?

Dr. **Fisk**. Yes, I would be very happy to answer that. We have in fact experienced considerable difficulties in recruiting at the top levels. There are somewhere between 6 and 10 vacant positions currently in my office at NASA Headquarters which I think we can safely demonstrate that we have been unable to fill principally because of the salary issue.

Let me cite some specific examples, the Director of our Microgravity Program. Here is a program in which we are depending on this person to be a recognized expert in the field and to lead the development of all the microgravity activities that will be flown in the spacelab and eventually the space station. More than half the use of the space station is for microgravity.

The salaries of people who have that sort of stature in the community are anywhere from 50 percent to 100 percent higher than current government salaries, and we have had no applicants for the job.

The Hubble Space Telescope, our large single flight project, we were unable to get anyone to be the Program Manager for that. We had to move a Program Manager off another flight program because of the importance of Hubble, and that has left that program uncovered, and you can go down list by list. There are simply positions that we cannot fill because the salaries as they are currently capped in the SES are so much lower than people with the right amount of experience on the outside.

Mrs. **Morella**. It's pretty outrageous, isn't it, when you consider that additional monies were put into the space budget.

Dr. **Fisk**. It is very poor economics.

Mrs. **Morella**. What are you trying to do about it? How are you going to cope?

Dr. **Fisk**. I wrote my Congressman and said please vote for the pay raise. [Laughter.]

Mrs. **Morella**. Well, I mean I have a bill in for the SES in the Judicial Branch that will increase it up to 20 percent. It doesn't do enough, but at least it shows some kind of recognition.

Do you have a deal with the Commission on Public Service, you know, that Paul Volker is leading in trying to talk about recruiting and retaining? Has there ever been any connection and would you know about that?

Dr. **Fisk**. I don't have any personal knowledge of that myself.

Mrs. **Morella**. Because they in fact will be coming out with recommendations.

Ms. Schmoll, I think you do.

Ms. **Schmoll**. There has been some agency connection with the Volker Committee, and I am not familiar with how far that has progressed, Mrs. Morella, but I know that that has occurred.

Mrs. **Morella**. Do you have any suggestions about what can be done other than just an across-the-board, according to the Quadrennial Commission, rankings and pay raise? I mean do you have latitude within your budget as, let's say, NIST has a pay program that allows a little latitude for adding. I mean can you take something from the budget and move it in any way at all?

Dr. **Fisk**. Absolutely not. I mean the most senior managers within our program are all senior executive services. There are 42 in fact within the Office of Space Science and Applications here in Washington, and those salaries are set by law. There is no way to change them and there is no way to add any fringe benefits to authorize honoraria or any number of things that one might do.

The difficulty that you face is we can do the simple things, you know, make people feel good, give them responsibilities, encourage them and pat them on the back. But, unfortunately, when it comes to the recruiting issue and you say I want to go into the outside community and find someone who has an adequate amount of experience and stature in the field to come to Washington, the basic question is can you convince them to take such a large cut in his salary and his standard of living, and the answer in many cases is no.

Mrs. **Morella**. So it's recognition, but it's also some remuneration that's important.

Dr. **Fisk**. Absolutely.

Mrs. **Morella**. If you could give me maybe sometime today or get someone to give me some of those specific examples that you have, I would like to pursue it further.

[The information follows:]

1. SES Positions Vacant Due to Salary Constraints: Deputy Director, Communications Division; Deputy Director, Earth Science and Applications Division; Director, Microgravity Science and Applications Division; Chief, Explorer Programs Branch; and Chief, Great Observatories Branch.
2. SES Losses Due to Salary Constraints: Assistant Associate Administrator (Space Station).
3. Non-SES Positions Vacant Due to Salary Contraints: Program Manager, Advanced Communications Technology Satellite; Program Manager, Mars Observer; Program Manager, Flight Systems.

Thank you very much.

Thanks, Mr. Chairman.

Mr. **Nelson**. You told me a minute ago about the Mars Observer that you were taking an instrument off, the visible infrared mapping spectrometer. How are you going to obtain the information?

Dr. **Fisk**. Let me back up just a moment on that. We went through, and I have to get my timing on this right, but I believe it was last summer, a very elaborate process of trying to assess how we would descope this mission in such a way as to minimize the impact on the science.

It is my belief that when we agree on what the price of a project is, what the runout cost is, that I have an obligation to deliver that project on that cost, and when we ran into cost difficulties we had to take the painful exercise of bringing it back by descoping.

In order to minimize the science impact, we convened the COMPLEX Committee of the Space Science Board, and COMPLEX stands for the Committee on Planetary Exploration. It's a standing committee of the Space Science Board of the National Academy of

Sciences to review the options that we have and give us advice. We exercised the judgment, but we have had science input at the time.

The conclusion was that it was an acceptable, not a preferable and certainly not a desirable activity to remove the VIMS and to descope the radar altimeter. Both those activities have occurred. The radar altimeter is being replaced with a laser altimeter at the moment which is looking very promising and meets our funding guidelines. In the case of the VIMS, we are currently having some discussions with the Soviets over the possibility of a smaller, but nonetheless scientifically similar instrument to fly on their Mars '94.

Mr. NELSON. So the answer is we will not get it from an American.

Dr. FISK. That's correct.

Mr. NELSON. But we may get it from a Soviet two years later.

Dr. FISK. That's correct.

Mr. NELSON. All right. Speaking of the Soviets, the Soviets are going to place biological experiments on a 1990 Space Shuttle. Tell us about that.

Dr. FISK. I'm going to ask Mr. Keller to answer that.

Mr. KELLER. If I may, Mr. Chairman, I believe the experiment you refer to is an agreement that we have with the Soviet Union to exchange data from certain rat experiments that will be conducted in zero G. I think this is a reference to a comment that was made in a press conference by a Dr. Ilian who is from the Institute of Biomedical Problems in Moscow talking a week or so ago at the Ames Research Center.

This is an entirely U.S. experiment that will fly on the Shuttle. It will expose rodents to zero gravity. We will exchange with the Soviets some of the results of that experiment, including some of the rodents. But it is part of an ongoing activity that we and the Soviets have over a period of some years exchanged data relevant to manned space flight.

Mr. NELSON. So it is not a Soviet experiment?

Mr. KELLER. It is not a Soviet experiment, no, sir.

Mr. NELSON. Is it a joint experiment?

Mr. KELLER. It is an experiment which we have agreed to share data.

Mr. NELSON. It's an American experiment of which you will share data.

Mr. KELLER. We will share some of the data, and in fact some of the rodents will be delivered to the Soviets, but it is a U.S. experiment.

Mr. NELSON. Will they be American rodents? [Laughter.]

Mr. KELLER. To the best of my knowledge, sir, they will be domestic rodents.

Mr. NELSON. There are not going to be of the 29 rats that you're going to fly, 5 of them are not going to be Russkies?

Mr. KELLER. No, sir. We will check their passports. [Laughter.]

Mr. NELSON. All right. I have a letter here from NOAA. They say they are turning off Landsat. What do you want to do about that?

Dr. FISK. Well, let me state that I think it is a national tragedy if we turn off the Landsats. What I would like to do about that is sincerely hope and encourage NOAA and in turn the Commerce Department to in fact continue that level of activity.

As you know, under the legislation that was passed, NOAA has the responsibility and, in fact, only NOAA has the responsibility to the operations of the Landsat system. It is getting close. As you know, the 31st of March if the date which these are to cease operations according to current plan, and the spacecraft are not safe. So that within a matter of weeks they will be lost and not recoverable.

I sincerely hope we do not get to that point, but it is under the law a NOAA responsibility.

Mr. NELSON. Well, Landsat doesn't run on encouragement. It runs on money. So what should be the policy of the U.S. Government?

Dr. FISK. Well, I would hope that the policy of the U.S. Government is to provide the resources through NOAA to be able to do this.

Mr. NELSON. And what are you specifically doing about it to see that that policy is implemented?

Dr. FISK. Every time I see NOAA I tell them they ought to fund this. This is a very complicated issue. As I'm sure you are aware, under the agreements that exist on this the data from Landsat is to be provided to the Eosat Corporation, which in turn sells it as a commercial venture. So when NASA acquires data from the Landsat, it does it as any other commercial customer, and it purchases it through Eosat at commercial rates.

So it is not simply a matter to say that NASA would in fact either provide funds, take over the tracking or any number of things associated with this for the simple reason that the data still belongs to Eosat and if we were trying to increase our data uses or benefit from this directly in our global change activities, that doesn't change in any way. That's simply the data goes to Eosat.

So the simple thing that has to happen here is that additional resources through NOAA to perform the tracking has to be provided, and then the data is in turn given to Eosat and NASA can continue to acquire it as it does. It should be noted that we actually make very limited use of the Landsat data at this point simply because the expense of purchasing this at commercial rates through Eosat limits our being able to use very much of this data.

Mr. NELSON. Could NASA provide the operational money with an agreement that it would be reimbursed once the data was sold?

Dr. FISK. I'm sure that many things are possible. There is nothing in either the 1989 or the 1990 budget which is very limited and, as we undoubtedly will discuss further here, is a very stripped version of our budget. There are no sums identified in either 1989 or 1990 to pick up this expense.

Mr. NELSON. I understand that. You have stated that it is clearly against the interests of the United States that they be turned off. NOAA is playing oh, poor me, and they say they are going to turn it off, and we are going through this drill again. We have had this battle for years now.

So if everybody is saying that it's clear in the interests of the country to keep Landsat going, why isn't somebody in the Administration coming up with a plan, and I have suggested something as one way of going about it, and you're saying the budget doesn't provide that. Of course the budget doesn't provide that.

So what do you do to try to formulate some rescue plan if this is in the interests of the country?

Dr. **Fisk**. Let's back up one step here though. I mean I think the witness that should sit here and defend what should happened to Landsat is the appropriate NOAA official, because legislatively NOAA has the responsibility. I mean NASA cannot even by law take over this activity. I mean I can't tell you that you can't ship money some place. I mean I suppose that's always possible, but it's not clear to me whose money ought to be shipped here in view of the fact that legislatively this is a responsibility of NOAA. I mean that was the arrangement that was set.

I think if you were to do anything differently than having NOAA fulfill its responsibilities on this activity, you would have to change the law.

Mr. **Nelson**. Mr. Skaggs.

Mr. **Skaggs**. Thank you, Mr. Chairman.

I know there were several Members ahead of me. I didn't realize we were to this point in the list.

If I could ask unanimous consent, Mr. Chairman, I have a copy of an editorial from the American Astronomical Society and some charts that I would like in the record so that I could inquire of Mr. Fisk about them.

Mr. **Nelson**. Without objection.

[The editorial and charts referred to follow:]

[EDITORIAL]

And Who Will Analyze the Data, II?

(By Jeffrey L. Linsky)

Should astronomy departments continue to practice "birth control", as many have for the last 10 years, or should they actively recruit students? The answer to this perennial question depends on the perceived future job market and the anticipated amount of federal research grant money for graduate students and postdocs. I believe that these perceptions should be re-examined in view of the rapidly changing funding environment.

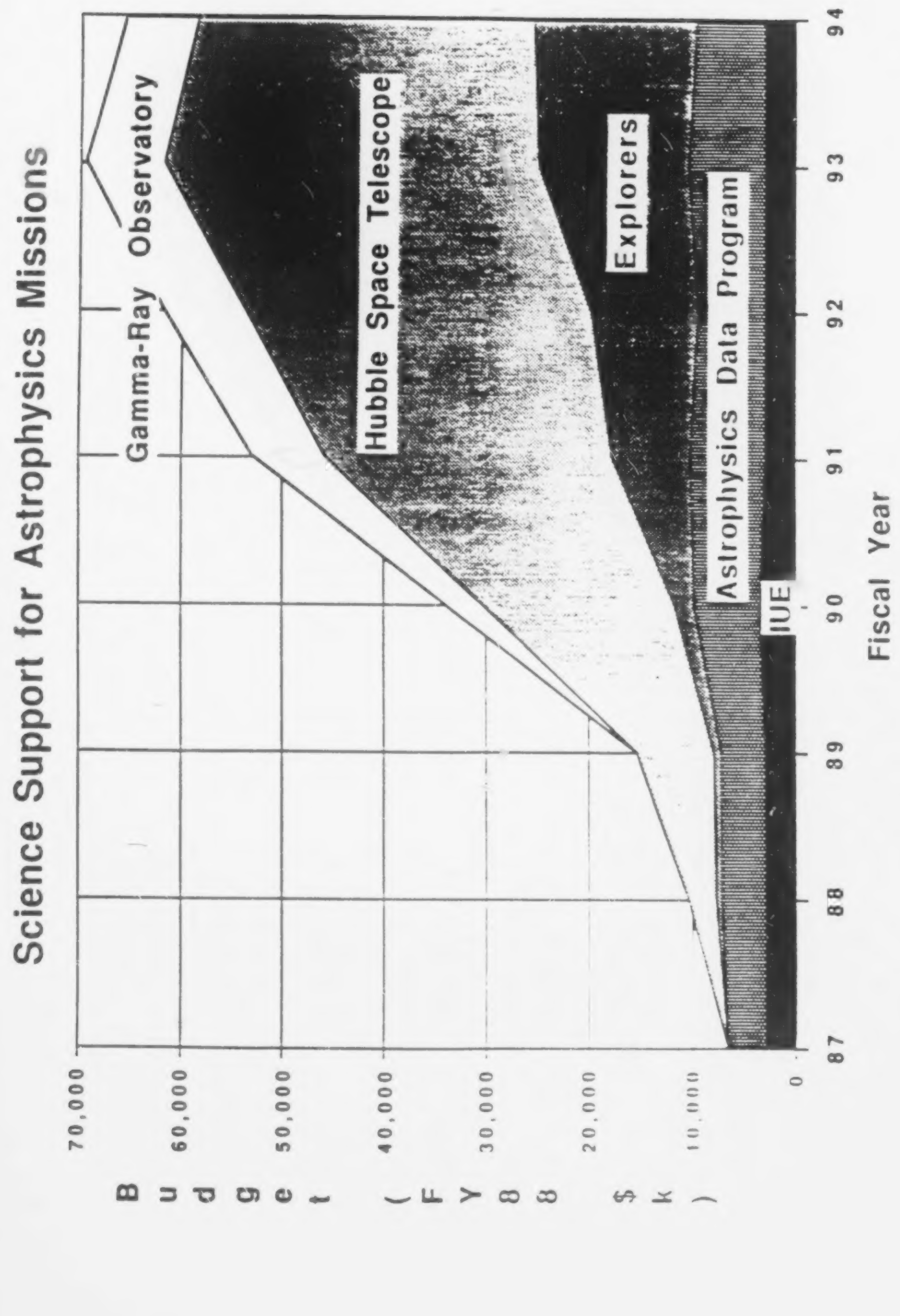
The NSF Astronomy Division now provides about $30 million per year to astronomers at universities to support theory, ground-based observing programs, and instrumentation development. The real buying power of this money, unfortunately, has been eroding at roughly 4 percent per year for the last six years, and the possibility of future erosion is a real cause for concern. If this were the only source of research funds then astronomy departments should practice "birth control".

NASA now provides about $12 million per year to universities to fund research with operating satellites (now only IUE), archival data analysis (for the HEAO, IUE and IRAS data sets), and theoretical astrophysics. NASA's programs in solar physics and planetary astronomy provide additional funds. This funding base will be supplemented by programs to fund the analysis of the enormous amount of data expected from future satellites.

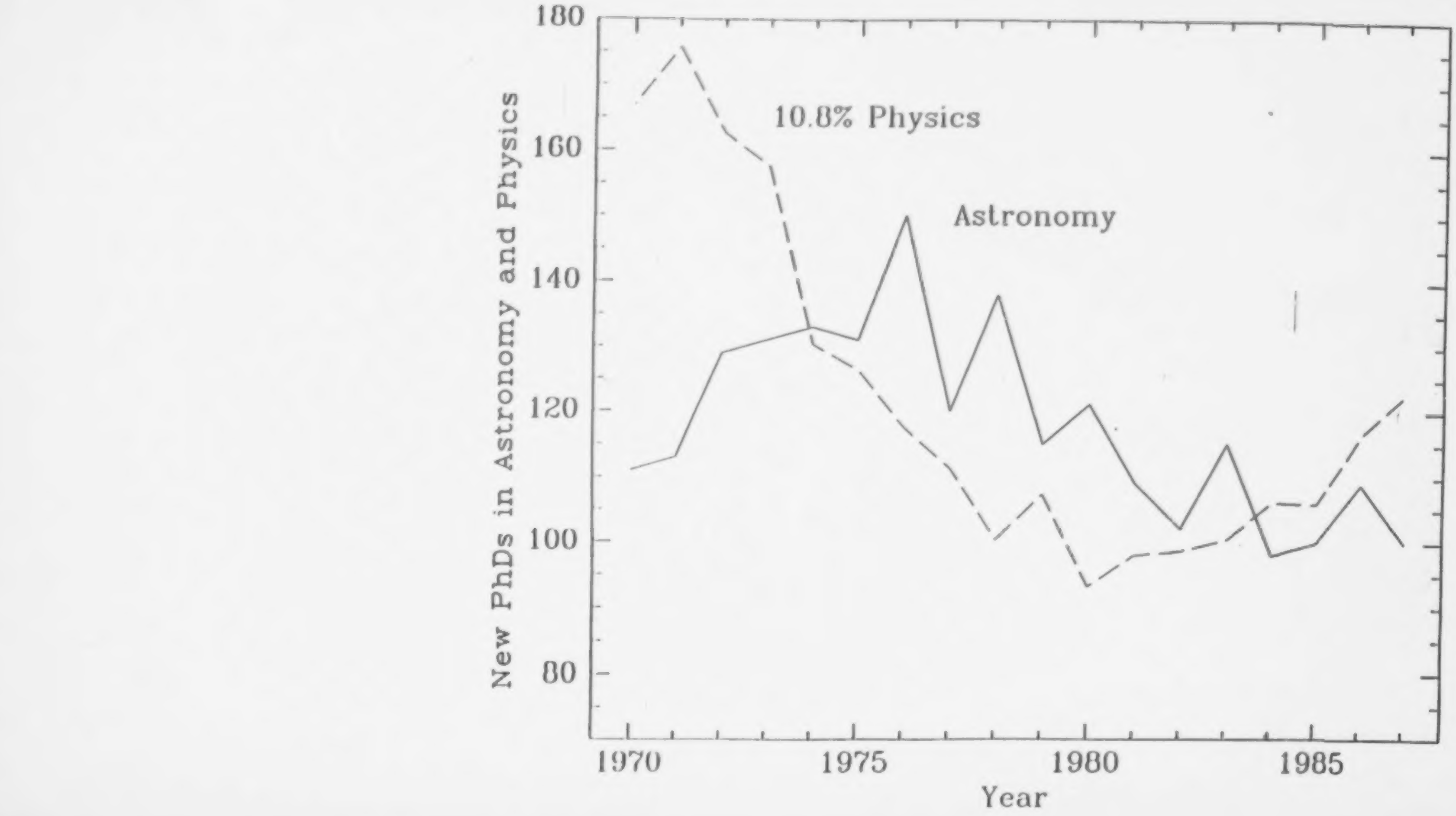
Present NASA plans as outlined by Charles Pellerin in this issue of the *AAS Newsletter,* call for a factor of five increase in the funds for astronomical data analysis over the next five years. Funding beyind this point should increase further with the launch of new long-lived missions like AXAF and SIRTF. Thus NASA's funding of astronomical research at universities could soon become twice that of the NSF.

All budget projections should be treated with skepticism, but the qualitative increase in the NASA data analysis budget has a high probability of success now that HST and GRO can be launched by an operational Shuttle and the smaller astronomy satellites will be launched with rockets. Moreover, these satellites will be enormously more sensitive than their predecessors. Responsible people at NASA recognize that a significant increase in data analysis funding is required to do justice to these data and to complement the very much larger hardware costs. Also, money for data analysis is rarely cut by Congress, because it funds investigators throughout the country.

The planned large increase in NASA's funding for astronomical research will be a revolutionary change comparable to the launch of Sputnik in its impact upon astronomy. Will there be enought talented graduate students and postdocs to analyze these data? Will universities create new tenure-track facility positions in response to this scientific and funding stimulus? I note that physics and astronomy departments will soon experience a large increase in retirements because of the big expansion in the early 1960s. My hope is that astronomers and university administrators will answer these questions with the important facts at hand.



Science Support for Astrophysics Missions


180
160
140
120
100
80
New PhDs in Astronomy and Physics
10.8% Physics
Astronomy
1970
1975
1980
1985
Year

Mr. **Nelson**. May I insert just a comment on this thought about Landsat. You know, this Administration has made a big deal about global change, and three different agencies are all talking about global change, and it was Planet of the Year on Time Magazine's cover. I mean if we are going to be serious about global change, then we have got to keep Landsat.

Dr. **Fisk**. I agree.

Mr. **Nelson**. Then I think you all had better go to work on that, and you better get your high priority boys walking down to the Oval Office and start getting them to understand the big picture and not lose the forest for the individual trees, and I will likewise and concurrently encourage Mr. Sensenbrenner as well with me to make those kinds of entreaties, but it's getting right down to the wire. Isn't it the end of March?

Dr. **Fisk**. Yes.

Mr. **Nelson**. Go ahead, Mr. Skaggs.

Mr. **Skaggs**. Thank you, Mr. Chairman.

Mr. Fisk, I have asked that you be given a copy of the document I just asked to be inserted in the record. There are three pages, and the second of the three that are stapled together indicates the projected budget for science support for astrophysic missions over the next five or six fiscal years, which shows the hope for a five or sixfold increase that we would be seeing over that period of time given the missions that are going to be coming on line.

The third page is another chart indicating the general decline in the number of Ph.Ds in astronomy and astrophysics that are coming out of our universities. The cover editorial in its last paragraph raises some interesting questions based upon those two charts, and let me just quote from that last paragraph.

"Will there be enough talented graduate students and post-docs to analyze the data that we are going to be getting? Will universities be expected on their own to have the resources to create the faculty and post-doc positions, or does NASA have a plan to boost these human resources that are going to be necessary if we are going to take advantage of all the good projects that we hope to have launched in that period of time?"

Dr. **Fisk**. You are addressing here I think a very important issue. When we say that we will be awash in new science data, I mean that is very much the case. We have in our runout budgets, both the budget that you have before you and the sort of five-year agreement that we have on this budget with the Office of Management and Budget calls for large increases in the funding to support those data analysis activities.

That of course then translates into people. You can divide your funding by the amount of money that it costs you to have a person plus the fringe benefits and the overhead and travel expenses and operation expenses and so on and translate this into people. The number of people that will be supported on the NASA program is scheduled to grow really quite dramatically, and in the case of astrophysics almost by a factor of five.

Now what will happen probably in practice is two things.

One, there are a large number of astronomers in this world and plasma physicists and people that are capable of doing this data analysis who will come and join the NASA program. So there is almost a kind of a mass migration anticipated in our future of people that are currently doing other activities, whether it's ground based or fusion research or some other things that will find the excitement and the challenge of space research so interesting that they will come and join our program.

So I'm not concerned particularly that we will have the right number of people to do this, but I do anticipate this migration occurring from other parts of the science establishment.

What is a concern to me, however, is the long-term future, and I have the concern in two regards. I think the excitement of the activities will cause people to go into science. The new students will see the discoveries coming from Hubble and from Magellan and Mars Observer and so on, and they will be attracted into science and that's very positive. On the other hand, we then have an obligation to make sure that there is a long-term successful science program for them to come and participate in.

A sort of a personal story. I am a Sputnik kid that graduated from high school in the late 1960's or late 1950's rather and went to——

Mr. NELSON. I was going to say this job has been harder on you than I thought. [Laughter.]

Dr. FISK. We were out there competing with the Russkies and everybody should go into science and so on. So I went off and got a degree in physics and I got a Ph.D. and I graduated in 1969, and I discovered I had gone from being a national asset to being a national liability in that time because the space program was in a turndown phase by the time I came out.

There is a long phase lag that sets in between you begin to excite students to go into the field and when they actually become working members of the field. One of the reasons that we laid down this Strategic Plan and we are trying to follow it is that it does in fact give us a space science and applications program which runs at a predictable and continuous level for the indefinite future.

So if people are attracted to the field by the excitement of all these launches over the next few years, if we are fortunate and follow the plan, there will be a space program for them to participate in when they get their education.

Mr. SKAGGS. I'm sorry I was late in arriving this morning. I assume you're referring to the hoped for schedule of a predictable program of new starts that will start to establish that plan.

Dr. FISK. Exactly. You ask yourself what does this plan imply for a launch rate if you do it correctly? Well, basically what you would want to do is one major new start each year, which 5 or 6 years from now translates into one major launch each year of a major program.

We also include in this small mission options for the Scout Class Launch Vehicles that will be launched at a rate of two a year. There is an occasional Delta Class Explorer which goes up every 2 or 3 years, and there are about four Spacelabs which are flown each year as part of the Microgravity and Life Science Research Program.

So the steady state version that results from this Strategic Plan is seven to eight launches per year for the indefinite future, the accommodation of spacelabs, major missions and small missions, and that is a very healthy space science program which would absorb new people coming in, as retirement set in on us in the late 1990's, mid-1990's and so on and I think guarantee a future.

Mr. SKAGGS. Getting back to my first question, is there any need, as you see it, beyond anticipating the migration from other fields into this area for NASA to have an explicit program directed to our university community that says this is where we are headed and these are going to be our resource needs, this is how much we think we are going to get from migration and this is how much we think you ought to be planning for?

Dr. FISK. Right. I think there are several things that we are already doing in this.

In the case of graduate student education, about 10 percent of all the graduate students in science, physics and so on in the United States are associated with the space program, and they are primarily funded by NASA. We have about 300 graduate fellowships and, in addition to that, our normal research grants and contracts support graduate students, and we continue to be one of the main funders of graduate education in science in the United States.

Now the other aspect though that I think as we have been looking at and have not made a decision of how to proceed, because you want to do the right thing here, is if you look at university faculties, one of the things you discover is that within about three or four years from now there is a massive amount of retirements that begin to set in. I mean many physics faculty group up in the Sputnik era and at the time that the baby boom was coming through, the early part, the universities in the 1960's. Enrollments were growing, science was interesting and physics faculties expanded at that time.

The result is, however, that the faculties are sort of single aged, and as a result now 30 years after the early 1960's, they are going to begin to sort of all retire at once.

Mr. NELSON. Dr. Fisk, I'm going to have to interrupt you. We are going to have to move on here.

Mr. Mineta has a question for you on Gravity Probe-B, and we've got to move on to Admiral Truly.

So if you would go on and zing in.

Mr. MINETA. Dr. Fisk, I want to thank you, first of all, for putting together a comprehensive cohesive plan in terms of where we are going on priorities, and the only problem with priority setting is that something always drops out. One of the things I see that has dropped out is this whole Gravity Probe-B program of where we have invested more than $25 million already, and I believe this year they are looking for roughly about $25 million, although hopefully we might be able to do it with less.

I was wondering why at this point again this was being dropped so unceremoniously?

Dr. FISK. Well, it is perhaps unceremonious and somewhat painful, but the issue that we face is that we have a budget level for space science and applications at 1,995 thousand dollars or a billion dollars. At that budget level we had to make some priority decisions as to what would in fact fit.

Now the Strategic Plan, as you point out, tells you how you are supposed to do that, and when you look at the Strategic Plan you realize that the new start, which is Gravity Probe-B, is one that will be difficult to obtain. It is a moderate mission, third in the list. We try and do major missions first. So the probability of there being a GP–B new start is less than there is for other of our potential new starts in the future.

So when we are in a position of having to live at 1995 for our total budget, that we then had to go back and say which is the ATD, the Advanced Technology Development programs. We looked at the one that supports GP–B, which is a Store program, and said that was the one that we had to cut out.

The alternatives, if I can finish just briefly, the alternatives were ongoing flight programs, which we never try and cut if we can can, our major new start, CRAF-Cassini, which we didn't want to cut, getting ready for space station and life science, which has a high priority for us and the activities that we are able to do across the university community for research and analysis funds, which again is a very high priority activity for us.

So when we were forced into a budget that was at 1.995 and we had to make decisions as to how to live within that, the Store GP–B was the one that was fingered.

Mr. MINETA. First of all, I don't consider this a new start. It has been an ongoing program. Just a month before you had the strong support of NASA in terms of NASA extolling the virtues of the program itself and how well it was run, and it has the support of the scientific community. So I was really surprised when all of the sudden this thing just dropped out.

Dr. FISK. Let's be clear on this issue. The program that was eliminated, that was cut was a program called Store. Store in itself is a technology development program and does not yield science. To have science you need to fund the Gravity Probe-B, which is a free-flying satellite. It will require a new start from OMB and from Congress, as would any major flight program.

So what we recognized in our Strategic Plan was that if we had to make cuts in our budget, we had to look at the program which we were least likely to get a new start from, and that's GP–B. So therefore we went back and sacrificed the ATD, the Advanced Technology Development program that is in preparation of GP–B. But there will be no science from this program unless we get at some point a new start for a mission which could cost in excess of $200 million, and that's GP–B.

Mr. MINETA. Well, I guess all I can do is belabor the point, the same point over and over again. It seems to me that here we have the Space Science Board supporting it. I sometimes wonder whether or not someone just said well, we've got to cut $25 million. Here is a $25 million program, Congress likes this program and they will put it back even if we cut it out. So let's go ahead and scratch this one. Frankly, I think it was that cavalier in terms of the way the Gravity Probe-B was handled. I think there is a lot of good research that has been done on this thing. We have a number of Nobel Laureates who are supporting this program, and I just am going to work very, very hard frankly to try and get this program reinstated in this year's appropriations bill.

Thank you very much, Mr. Chairman.

Mr. NELSON. We have suggested that similar kind of thinking went into the ACTS omission, which we go through that drill every year.

We would like, Mr. Fisk, a Strategic Plan from you as to how you are going to process all this data that is coming in in increasing volumes into you.

Dr. FISK. Let me, if I may, I recognize the same issue as being one that we need to be concerned with. When we developed the Strategic Plan for Space Science and Applications last year, one of the deficiencies that we saw in that plan was that there needed to be a separate Strategic Plan for handling the data that is coming down, just this onslaught of data, and what technical issues should we be addressing and where should we be placing our investments in new technologies, where it's networking, computers or what-have-you.

So we chartered a separate Strategic Plan exercise which begin last fall for the purpose of developing a Strategic Plan for the information systems activities. The first draft of that report is anticipated in about the June or July time frame and it will feed then in a final report into the fall process. Remember we do strategic planning on an annual basis, and we update our Strategic Plan. The one that you have at the moment is the 1988 one.

The 1989 one will come out in the early April time frame. It is not different in terms of priorities, as you would expect, because it's a five-year plan and we are living by it.

The strategic planning activity for information systems will complete this summer in a final report and that will then feed into the development of the 1990 Strategic Plan for Space Science and Applications which completes in the spring of a year from now.

Mr. NELSON. Dr. Fisk, that is a lot of words. What is the answer to my question, and my question is we want a Strategic Plan from you on how you are going to handle the data. Now what's your answer? When is that plan coming?

Dr. FISK. Approximately in the summertime.

Mr. NELSON. Then that's an easy answer. That's an easy answer.

Dr. FISK. I was a university professor, and you can't give a simple one. [Laughter.]

Mr. NELSON. But we are a Congressional Committee and we have one of your colleagues who has been sitting there for the last hour and 45 minutes waiting to testify.

Now if you would move over right there, we want Admiral Truly to come up. We don't want you to leave because we have Mr. Nagle here and he may have some further questions for you.*

So Admiral Truly.

We will put your statement in the record. We also have some questions submitted by other Members of the Committee that will be submitted to you in writing, Dr. Fisk.

Admiral Truly, do Naval Admirals take as long to answer a question as University Professors? [Laughter.]

Admiral TRULY. No, sir. [Laughter.]

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*Appendix 2 contains additional answers to questions asked of Dr. Fisk following this hearing of Mar. 1, 1989. See p. 1134.

But I did want to encourage you from the front row to just continue talking to Dr. Fisk. [Laughter.]

Mr. **Nelson**. Please proceed.

STATEMENT OF ADM. RICHARD H. TRULY, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE FLIGHT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY JOSEPH B. MAHON, DEPUTY ASSOCIATE ADMINISTRATOR, FLIGHT SYSTEMS, NASA; ARNOLD ALDRICH, DIRECTOR OF NATIONAL SPACE TRANSPORTATION SYSTEMS, NASA

Admiral **Truly**. Mr. Chairman, with your permission, I would like to submit my written statement for the record, but I would like to, if I may, make a few brief comments to the Committee about this year's Office of Space Flight budget, if that is all right.

I am pleased to be here and want to say from the beginning that this past year has been a year of significant achievements from the Office of Space Flight and a year that I am extremely proud of.

We have seen the Shuttle recovery during the past year. 1988 was a year of two for two with two Shuttle flights, and they were two outstanding flights. The Office of Space Flight was eight for eight last year with six successful ELV launches, and all of those missions are also going well, and plus of course the two outstanding Shuttle missions in September and December of last year.

Furthermore, to the south of here Discovery is on pad 39-B today. We are doing to fly a second tracking data relay satellite in the middle of March, and as a matter of fact, Mr. Arnie Aldrich, who is here to my left, is the Director of the Shuttle Program, and I are going to be leaving Washington this afternoon when you hearing is complete and going to the Cape and conduct a flight readiness review for this upcoming mission.

I want to assure your Committee that we are addressing the go-for-flight, if you will, and the rigor that we are applying to this mission just as we did for STS-26 last September, and we intend to keep doing that.

If I can make the most important point possible of the things I would like to point out, I would like to say that our successes in the Shuttle program are a direct result of the technical and operations management and the process that we have put into place, and the structure that is in place in the program which Arnie Aldrich has led. It's built on a rigorous ground test program, not in solid rocket motors, but in main engines and in avionics.

Our real strength underlying this effort is a strong institutional base, and by that I mean in the Office of Space Flight about 9,700 dedicated civil servants and associated support contractors. In the budget there is a line item that usually is not very debatable, but it's called an ETB, or our Engineering Technology Base, and it's this part of our budget that supplies quality people, decent facilities for them to work in and laboratories, and I consider it most important.

Our challenge as flights increase I believe is that we must fund and maintain this underpinning of this program which is so successful till now to avoid complacency, make sure the lines of responsibility are kept clean, both up and down, and I believe that the payoffs will be enormous.

As I mentioned before, we were eight for eight in 1988, and I think that shows that we are vigorously pursuing our mixed fleet, in other words, the proper balance of Expendable Launch Vehicles and Space Shuttles.

I want to remind you that we are purchasing launch services, commercial launch services from the private industry, which has been a real success story, and that has been led by my Deputy for Flight Systems to my right here, Mr. Joe Mahon. In Flight Systems Joe not only manages our Expendable Launch Vehicles, but also our upper stage programs and other programs, such as the OMV, the Orbital Maneuvering Vehicle.

In the future we will be obtaining Expendable Launch Vehicles through the DOD only when those vehicles are not made available to us in the future from commercial companies. So we have seen a lot of successes in 1988 for that and I'm proud of it.

We do have a lot of challenges.

In January just, I guess since this is the 1st of March, just two months ago we issued a new NASA manifest that shows between today and for the next 5 years through 1994 that we have just over 60 Shuttle flights planned and a slowly increasing buildup of flight rate, and about 29 Expendable Launch Vehicles during that same period.

Therefore, you can see from my first point where I believe it's so important that we continue to support the underpinnings and the people in the facilities and the things it takes to run this part of NASA's program.

The Shuttle program, I might point out, is not a stagnant one. We are planning for the future in adding new capabilities where we can afford them and putting margin into the system and reliability and quality and safety.

We have the Advanced Solid Rocket Motor that I know is of great interest this year since its full funding year, and we can discuss that at your pleasure.

The Extended Duration Orbiter is part of the Shuttle program of course.

I might say, most importantly, even though it's not a budget issue for the fiscal year 1990 budget, we are building a replacement vehicle for the Challenger in Palmdale, California today. It's OV-105 and we will name that vehicle based on recommendations from school kids across the country, which is one small way that we are trying to encourage really young people to do little space projects, and as a reward for that have the ability to turn in a suggested name for this new Shuttle.

The OV-105 vehicle is on schedule. It is running just under cost. We plan to roll it out in the summer I believe of 1991 and it will go to the Cape, be checked out and have its first flight in the winter of 1991-92.

Our business is an exciting one, and we are also within the Office of Space Flight, and I fund it through my office, are looking to future options so that the United States can remain in the 21st Century able to do those exciting things, and of course our part of this business is space transportation.

We are working in a joint program with the DOD, and with agreements with the Congress and the DOD we are receiving significant funding in the Advanced Launch System for particularly in focused technology and in liquid engine development, and we are today building facilities, early facilities for component tests done at the Stennis Space Center.

We are also are studying a vehicle which I know is of great interest, which we call Shuttle-C, "C" for cargo. It's a simple idea, and that is that we use the things that we now have, that is rockets and tanks and facilities and launch pads and so forth, replace the Orbiter with a large payload shroud, and with the least development cost we would get the highest reliability, but low flight rate U.S. capability and heavylift, and by heavylift I mean 100,000 pounds with two main engines or up to about 150,000 with main engines on an East Coast launch.

It's not too soon for the Congress and we and the public to begin to debate on what we will do in the future for manned space travel because development times for new vehicles range from 10 to 12 years at a minimum, and I think in the next 2 to 3 years, perhaps not this year, we will need to have this debate, and we are moving out now to look at manned transport.

Obviously one attractive course would be simply to evolve the Space Shuttle in which we have such an investment, and by evolve it I don't mean put twin tails on it or aerodynamic canards, but I mean keep the production line open and look at ways that we can improve the margins and as our avionics as these decades go by become obsolescent to evolve it. That's an option. Another option would be to replace the Shuttle with a smaller people carrier, if you will, balanced by smarter Expendables that can do rendezvous and proximity operations, and of course, finally, we could get out a new sheet of paper and use the new technology that America is developing.

As I said, these future vehicles are not necessarily a part of today's budget, but I want to tell you that we have not forgotten the future and we are looking hard at it. As we move out to the years when we will from the shuttle assemble the space station, we think we are in good shape now and we do have a lot of challenges.

So in summary I would say that we are back in business. The next chapter in our flights will be in just a few days, and we are going to do a rigorous flight readiness review to make sure it's safe to fly that vehicle, but we have lot more exciting missions even in this year.

Our successes are built on the systems we put in place, particularly the people, the institutions and the facilities, and we need your support in that regard, and we are looking to the future.

Finally in summary I might say that I have never seen a tighter budget management situation that Arnie Aldrich and Joe Mahon are faced within 1989, and I see the same situation in 1990. So we very much need yours and the Committee's help for the future.

[The prepared statement of Admiral Truly follows:]

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PRESENTED BY WITNESS

Statement of

Richard H. Truly
Associate Administrator
Office of Space Flight

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science, Space, and Technology
House of Representatives

Mr. Chairman and Members of the Subcommittee:

I welcome this opportunity to review with you the programs of the Office of Space Flight (OSF). I would like to review the significant achievements and progress we made in 1988, highlight concerns I have about the challenges we face this year and beyond, and outline the OSF's Fiscal Year 1990 budget request.

Let me first note a few essentials:

- Our 1988 launch record was 100 percent--eight successes! Six missions used Expendable Launch Vehicles (ELVs) and, most significantly, we safely returned the Space Shuttle to flight status with two outstanding missions. The Shuttle enables the United States to dramatically expand our capabilities in space with the men and women who bring to Earth orbit creativity, imagination, and dexterity. The Shuttle does many jobs--all of them well. Today, DISCOVERY is undergoing final preparations for our first 1989 flight, scheduled in just a few short days.

- Our successes are a direct result of the technical and management structure and process we have put in place. This, along with our rigorous test and qualification program, has been key to our achievements. The real challenge for us all, as flight rate increases, is to properly fund and maintain this activity and organization; we must forever avoid complacency and insure the clear delineation of responsibility and attention to detail.

- NASA's mixed fleet strategy is being implemented with vigor. The mixed fleet combines Space Shuttle flights with unmanned launch services obtained from the commercial sector to provide the best transportation balance for the civil space program. Only where commercial launch services are not available do we procure unmanned vehicles through the Department of Defense (DOD).

- NASA's flight schedule for the Space Shuttle missions through FY 1994 numbers over 60 Shuttle launches. Our unmanned launch vehicle programs encompass 29 launches during this same period. This schedule illustrates how vital space is to our country. This situation challenges us technically, operationally, and fiscally.

- Our program successes continue to require a strong institutional base. Some 9,700 civil servants plus associated support contractors constitute the real strength of the OSF. Meeting our institutional requirements (quality people and good facilities they can work in) continues to be a management challenge.

- American leadership in space transportation cannot be taken for granted. International competition has become intense. The United States must invest in new technologies and new systems to meet national objectives as we approach the twenty-first century. The international competitors are continuing to develop their capabilities.

- Durable as they are, the current Shuttle fleet will not last forever. In the twenty-first century, improvements in space transportation will be required to support our evolving national requirements, such as the long-term goal of expanding human presence and activity in space. It will take at least ten years to design and build new systems if required. It is timely now to begin thinking conceptually about what is needed and our options for the future.

- Finally, space flight cannot be made risk free. The return-to-flight program has allowed NASA to assess and better understand the nature of the risk, then reduce it to prudent and acceptable dimensions. I am very comfortable that we have struck a good balance, and we pledge to maintain safe and sustainable operations as we increase the flight rate to support the nation's civil space operational requirements.

We have undergone a major transition in the past three years. The OSF and its programs are vastly improved from the standpoint of structure and procedures. Last January we completed the final full-scale test of the Redesigned Solid Rocket Motor (RSRM). Throughout the tests, and on the two Shuttle flights last year, the redesigned hardware performed as predicted. Those flights, and the six successful ELV flights of 1988, have reassured us that we are on the right path. We all recognize, however, that a great deal remains to be done. In that spirit, we seek the Subcommittee support in sustaining in FY 1990 the momentum that we have accumulated and are so proud of.

I would now like to review our FY 1990 budget request:

OSF FY 1990 BUDGET REQUEST

The OSF FY 1990 budget request is $4,676.5 million. We request $4,037.5 million under Space Flight, Control and Data Communications (SFC&DC) and $639 million for Capability Development, funded under the Research and Development appropriation. The SFC&DC request is divided into two elements--$2,732.2 million for Space Transportation Operations and $1,305.3 million for Shuttle Production and Operational Capability. Programs and activities funded under these categories are:

- SPACE TRANSPORTATION OPERATIONS--supports Shuttle Flight Operations, Flight Hardware, and Launch and Landing Operations, as well as procurement of Expendable Launch Vehicles and Services.
- SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY--provides the capability to fly safely at the projected flight rates. Funding is identified separately in Orbiter Operational Capability, Propulsion Systems, and Launch and Mission Support.
- SPACE TRANSPORTATION CAPABILITY DEVELOPMENT--provides for effective use of and improvements to our operational capabilities. Funding is included for Spacelab development and operations, upper stages for both the Shuttle and ELV's, the necessary Engineering and Technical Base, Payload Operations and Support Equipment, and studies of new capabilities including Advanced Programs and Advanced Launch System (ALS), as well as development of the Tethered Satellite System (TSS) and the Orbital Maneuvering Vehicle (OMV).

To put this request in the proper context, a discussion of our flight manifest is in order.

NASA's FLIGHT MANIFEST

In the past three years, you have watched the NASA mixed fleet manifest mature. The Shuttle projected flight rates have stabilized at five to nine per year in FY 1989-1991, increasing to 14 in FY 1993 after the new orbiter begins operation in 1992. The ELV flight rate averages about five per year. Payload programs have adjusted their schedules and budgets to match flight opportunities.

Our most recent manifest covers the years FY 1989-1994 and includes flights (for NASA, NOAA, international customers, and DOD) on Shuttle and ELVs. It shows the accommodation of 29 spacecraft on ELVs and 129 payloads on Shuttle. These flights represent the full range of space program objectives--national defense, astronomy, astrophysics, earth sciences, planetary exploration, life sciences, microgravity materials research, communications, weather observations, navigation, advances in space technology, and the expansion of human presence in space. A number of payloads directly support commercial initiatives in space.

Studies are under way to define the best manifest balance (manned and unmanned) for the challenging years beyond FY 1994 when we will assemble, build, and operate Space Station Freedom.

SPACE TRANSPORTATION OPERATIONS

Of the $2,732.2 million requested for Space Transportation Operations, $772.6 million is for Shuttle Flight Operations, $1,236.5 million for Flight Hardware, $553.6 million for Launch and Landing Operations, and $169.5 million for Expendable Launch Vehicles and Services.

Flight Operations

Flight Operations supports the planning of control for each Shuttle flight for which we request $772.6 million in FY 1990. In the mission support area, preflight mission planning, training, and operations control activities are provided. Tasks include flight planning, systems and software handbook preparation, flight rules and procedures, Mission Control Center (MCC) and network requirements, and operations planning for selection and operation of Shuttle payloads. Also included are the maintenance and operation of critical facilities such as the MCC, Shuttle mission simulator, and the software verification facilities.

Integration includes orbiter sustaining engineering, payload and system integration, launch support services, and development and verification software. Sustaining engineering provides prime contractor engineering activities necessary to qualify the orbiter for flight, as well as flight verification and analysis tasks. Orbiter software activities include development, formulation, and verification support, plus base operations support at our field centers. Base operations provides orbiter engineering and support, crew equipment, flight operations systems, and support to the Space Shuttle program office, plus aircraft operations.

Flight Hardware

The FY 1990 request of $1,236.5 million is directly related to the Shuttle flight rate. This includes orbiter spare parts, replacement of consumed hardware, repair and logistics operations, maintenance schedules, and operational usage, taking into account lead times to procure or repair flight hardware. The budget provides replenishment, line and shop replaceable units, plus the manpower to support the overhaul and repair activity for the orbiter, extravehicular maneuvering unit, and other crew equipment. Funding also provides main engine refurbishment overhaul, as well as replenishment or repair of engine component spares and flight support.

Flight Hardware provides the Solid Rocket Booster (SRB) and External Tank (ET) requirements including major element and materials procurement and labor for required refurbishment and manufacturing. The SRB project will deliver six flight sets in FY 1989 and nine in FY 1990. The ET will remain at the minimum delivery schedule of four tanks per year through FY 1990. These projects have extended manufacturing cycles and long-lead materials procurements. As a result, a significant part of FY 1990 funding supports the increased flight rates planned for subsequent years. The first flight support motor static firing test will be conducted in FY 1990 to monitor the consistency of RSRM production characteristics and to provide a continuing engineering data base to enhance program safety.

Launch and Landing Operations

The $553.6 million requested for Launch and Landing Operations provides manpower and support services necessary for processing launches. This includes SRB assembly, ET/SRB/orbiter mate, orbiter processing, integrated vehicle checkout through launch, SRB retrieval, and landings. Landing support includes safing and deservicing and downloading mission-unique experiments and payload carriers.

Expendable Launch Vehicles and Services

A two-phased plan to implement the mixed fleet ELV program is under way. In the first phase, four Shuttle payloads: Roentgen Satellite (ROSAT), Extreme Ultraviolet Explorer (EUVE), Combined Release and Radiation Effects Satellite (CRRES), and a second phase payload, Mars Observer (MO), were transitioned to ELVs. In the second phase, NASA plans procurement of launch services directly from commercial ELV operators in three performance classes: small class (payloads up to 1,000 lbs. into low earth orbit); medium class (payloads up to 10,000 lbs.); and intermediate class (payloads up to 30,000 lbs.). NASA missions in the large performance class (payloads 40,000 lbs. or more) will continue to be acquired through the DOD, as none are available from the private sector.

The ELV budget request for FY 1990 is $169.5 million. FY 1990 funds will continue activity on the CRRES, MO, and EUVE missions; launch the ROSAT; continue procurement of commercial launch services for medium-class GEOTAIL, Polar WIND, and MSAT; and the small-class Office of Space Science and Applications Explorer missions. Initial mission integration activities for a Titan IV launch of CRAF and an intermediate-class launch of Solar Heliospheric Observer (SOHO) in 1995 will also be started.

In strong support of ELV commercialization, NASA negotiated and signed the nation's first commercial launch services contract in mid-1988 for a series of Geostationary Operational Environmental Satellite (GOES) missions. We also negotiated the government's first barter exchange of residual launch vehicle production and flight hardware assets for commercial launches for the Fleet Satellite Communications (FLTSATCOM-8) payload and CRRES. We are currently negotiating for a commercial Titan III for launch of the MO spacecraft in FY 1992.

During 1989 we will launch the Cosmic Background Explorer (COBE) mission. COBE will use funds reimbursed from residual Delta vehicle hardware. On Scout we will launch two Navy missions, MACSAT and SALT, and on Atlas/Centaur we will launch the last DOD FLTSATCOM payload. Activity continues on procurement of Delta IIs through the USAF for launch of the ROSAT and EUVE missions in FY 1990 and FY 1991. We plan to competitively select private sector operators to provide commercial launch services for our small and medium-class out-year missions.

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY

The $1,305.3 million requested for Shuttle Production and Operational Capability is planned as follows: $237 million for Orbiter Operational Capability, $727.3 million for Propulsion Systems, and $341 million for Launch and Mission Support.

Orbiter Operational Capability

$157.5 million of this request will provide for completion of previously approved systems improvement programs, necessary safety modifications, and engineering analysis and integration capabilities to support the flight rate. Examples of improvements initiated even before the standdown are the star tracker, carbon brakes, and an improved inertial measurement unit, plus new general purpose computers which become operational in 1990.

The Extended Duration Orbiter (EDO) request is $25 million. We have initiated necessary work to provide the capability of OV-102 (COLUMBIA) to stay on orbit up to 16 days. The EDO adds a cryogenic pallet for additional power generation and modifications of waste management and environmental control systems. We plan to "scar" the replacement orbiter, OV-105, as it is being manufactured, to provide a backup to OV-102 and to enable progress beyond the 16-day capability. This program was initiated in FY 1988, and the FY 1990 request assumes private sector investments in the EDO program.

$30.3 million will provide ongoing procurement and fabrication of orbiter spares and a logistics system to support the operational flight rate. A logistics depot, established near the Kennedy Space Center (KSC) for repair and maintenance of flight and ground support hardware, will reduce costs and shorten turnaround time.

$15.2 million for structural spares is planned to initiate fabrication of a new set of structural assemblies to replace those in use in the production of OV-105. This effort, beginning in FY 1989, will provide a minimum capability to produce another vehicle, plus provide additional hardware for inventory and orbiter subcontractor retention to support orbiter production. A $9 million request for systems integration funds covers all redevelopment analyses and analysis of hardware changes, as well as development of a Systems Integrity and Assurance Program to provide management visibility into the critical parameters of hardware and systems performance.

Propulsion Systems

The FY 1990 request includes $496.6 million for the Space Shuttle Main Engine (SSME), which includes continued testing and evaluation of hardware as well as improvements to the current SSME. The SRB funding request of $106.7 million focuses on continued evaluation and analysis of flight data to assess the redesign, continued improvements to the Solid Rocket Motors (SRM) manufacturing process, and reclamation or replacement of pre-Challenger reusable hardware. The ET request of $2.7 million supports the hardware production with acquisition of off-the-shelf test and manufacturing support equipment.

The Advanced Solid Rocket Motor (ASRM) program will be funded at $121.3 million under this request. The ASRM will provide enhanced safety, reliability, and increase performance through the life of the Shuttle program. The Request for Proposal (RFP) for the ASRM development production phase was issued in August 1988, and a winning contractor team will be selected, with contract award anticipated during the spring of 1989. Under the ASRM acquisition plan submitted to the Congress on March 31, 1988, alternatives under consideration include methods to finance the facility through the private sector, but specifically retaining the government's ability to recompete the contract in future years. Facility construction, motor design, and development of the new motor is planned to begin in FY 1989. The development program is anticipated to extend for five years, with the first flight in late 1994. The ASRM development rests on a far more mature technological base than that available in the 1970's at the start of the original SRM project.

Launch and Mission Support

$341 million is requested for Launch and Mission Support. This supports Johnson Space Center (JSC) mission operations capability development at $166.9 million and mission support capability items at $75.6 million. Major facility modifications and launch site equipment at KSC require $98.5 million to provide more efficient launch processing operations. The current Orbiter Maintenance and Refurbishment Facility is being upgraded to be a fully operational Orbiter Processing Facility by the fall of 1991, just prior to the fleet introduction of the replacement orbiter.

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT

Our FY 1990 request for Research and Development funds under Space Transportation Capability Development is $639 million. This amount supports $98.9 million for Spacelab, $88.6 million for Upper Stages, $189.8 million for Engineering and Technical Base, $81.1 million for Payload Operations and Support Equipment, $48.7 million for Advanced Programs, $5.0 million for ALS, $19.9 million for TSS, and $107 million for OMV.

Spacelab

The Spacelab request is $98.9 million in FY 1990 and will support flight opportunities created by an increase in the allowable orbiter downweight capability and a reduction in DOD flight requirements.

Preparations for NASA scientific, DOD (Starlab), and international missions are in process. The next NASA Spacelab mission, Astro-1, scheduled for mid-1990, will be the verification mission of the igloo pallet configuration. Additional flight hardware, direct mission and mission-related manpower, and payload operations control center activities are required to support the FY 1990 Space Life Sciences (SLS-1) and the FY 1991 (Atlas-1) missions.

Also scheduled during 1990 are a DOD Spacelab mission, a Get-Away Special bridge support structure, and several Hitchhiker missions. The enhanced multiplexer/demultiplexer pallet, part of the Spacelab pallet system, will be verified with the TSS mission in early 1991. We work toward an FY 1991 launch of the next international Spacelab module mission, Spacelab-J, a combined Japanese/NASA life sciences and microgravity mission, and begin preliminary integration efforts on the USML-1 (United States Microgravity Laboratory) to be launched in early calendar year 1992. The 16-day EDO capability is targeted to support this flight. We continue to work with the European Space Agency, builder of the Spacelab system, for spares procurement and operation of the depot maintenance program for U.S.-provided and European-supplied hardware.

Upper Stages

The Upper Stages budget request for FY 1990 is $88.6M. The Upper Stages program is composed of Inertial Upper Stages (IUS) and Transfer Orbit Stage (TOS) procurement and a Solid Propulsion Integrity Program (SPIP). Upper stages boost payloads to orbits and trajectories not attainable by the Shuttle or ELVs alone. Requested funds will procure stages and provide technical monitoring and project management. IUS vehicles are procured through the DOD.

The TOS program is a commercial venture by the Orbital Sciences Corporation (OSC), and these vehicles are procured directly from OSC. The SPIP project, initiated in 1984, establishes an engineering base for improving the success rate of U.S.-built solid stages, and we have carefully coordinated with the DOD to avoid duplication of efforts in this vital program.

In FY 1989, production of IUS will continue for the Tracking and Data Relay Satellite (TDRS) -E and -F Galileo and Ulysses missions. In addition to IUS, Ulysses will use a modified Payload Assist Module (PAM), a commercial upper stage produced by the McDonnell Douglas Astronautics Corporation. We will launch two IUS missions in FY 1989 aboard the Space Shuttle, (TDRS-D and Magellan). The TOS upper stages for the Advanced Communications Technology Satellite (ACTS) mission and the Titan III launch of the MO mission will continue production in FY 1989. No funds have been provided beyond FY 1989 for continued procurement of a TOS for ACTS. The SPIP program will continue work on building the engineering base on solid propulsion stages in the areas of nozzles and bondlines, propellants, combustion dynamics, and verification testing.

The FY 1990 funding request will support the IUS/Galileo launch, preparation of the IUS/PAM-S/Ulysses for an FY 1991 launch, and completion and storage of IUS vehicles for the TDRS-E and -F. The TOS for the MO mission will continue production for launch in FY 1992. The SPIP will expand its investigation by examining materials, design tools, fabrication processes, and controls. It will examine product evaluation and verification methods and improve engineering practices, procedures, and communications within the nation's solid propellant community.

Engineering and Technical Base

A strong Engineering and Technical Base (ETB) is essential to the continued success of the Space Shuttle and all current manned space flight programs. It provides an absolutely critical foundation for our space efforts, including our core ability to build Space Station Freedom.

ETB provides the core capability for the engineering, scientific, and technical support at JSC in Texas; KSC in Florida; Marshall Space Flight Center (MSFC) in Alabama; and Stennis Space Center (SSC) in Mississippi. This support consists primarily of contractor manpower to operate and maintain facilities and laboratory equipment.

The ETB core varies from center to center due to programmatic and institutional differences. At JSC, ETB provides for five-day/one-shift operations in the engineering and development laboratories (such as the Electronics Systems Test Laboratory and the thermal test area), as well as at the White Sands Test Facility. ETB provides centerwide computational services and for Safety, Reliability, Maintainability and Quality Assurance (SRM&QA) support for the OSF.

At KSC, the core level primarily provides for technical laboratory support in such areas as launch equipment testing, materials testing and malfunction analysis, robotic applications for payload preparation, and digital electronics test and evaluation as well as SRM&QA support. At MSFC, the core level provides for multiprogram support to technical laboratories and facilities and to test facility operations. ETB funds also provide for computational services at MSFC as well as SRM&QA support. At SSC, ETB funds continue SSME test support as well as the technical base supporting the ASRM program and ALS technology development.

The FY 1990 funding request of $189.8 million provides necessary capabilities at each of the OSF centers and is needed to:

- o meet increasing SRM&QA requirements due to implementation of the Rogers Commission recommendations, processing of three orbiters in flow, and providing independent flight software assurance.
- o continue the enhancement and development of Class VI computer capabilities used to support multiple programs.
- o provide a minimal increase of support contractor manpower to meet requirements associated with new and enhanced facilities and laboratories.

Payload Operations and Support Equipment

Payload Operations funding of $60.4 million will furnish continued payload services for currently scheduled launches. Major NASA payloads receiving support during this fiscal year include Hubble Space Telescope, TDRS, Galileo, Ulysses, Space Radar Laboratory, Space Life Sciences Laboratory, Upper Atmospheric Research Satellite, and Gamma Ray Observatory. Provision has been made to replace outdated engines on the Super Guppy aircraft required for ferry of outsized payloads. Funding is required to assure compatibility between Shuttle capabilities and Space Station Freedom transportation requirements. Initial efforts and under way to support development of a standard orbiter docking system to be used by Space Station Freedom and other on-orbit docking requirements. The payload support equipment requirement of $20.7 million is to upgrade selected payload capabilities for safer, more efficient operations. FY 1990 funding for multimission payload support equipment is required to develop, test, and deliver Payload Common Communication Equipment (PCCE) to accommodate required payload data transmission and initial spares provisioning for cargo integration test equipment and PCCE. Funds for fiber optic cabling and an upgraded operational intercom system at KSC provide increased data transmission reliability among cargo facilities.

Advanced Programs

The Advanced Program Development request is $48.7 million in FY 1990. Studies of future space transportation and related requirements are the focus of this program area. In FY 1990, emphasis will be on advanced space transportation systems, advanced operations support systems, satellite servicing systems, and advanced missions.

In advanced space transportation, preliminary design studies begin this year for the Assured Crew Return Capability (ACRC). We will continue to study in detail vehicle concepts required to meet medical emergencies.

Conceptual studies will also be initiated this year to investigate three alternate approaches for civilian manned transportation system evolution. These studies will pursue concepts for evolution of the current Shuttle, a smaller personnel launch vehicle, and an advanced manned launch system.
We believe an unmanned heavy-lift launch capability is very much in the national interest. The Shuttle-C concept NASA has identified would provide a near-term capability to boost between 100,000 and 150,000 pounds with comparatively low cost and low risk. System definition for Shuttle-C will continue through FY 1989.

NASA is also studying options for transportation capabilities to suport the Administration's policy to expand human presence beyond low Earth orbit into the solar system. Evolutionary concepts for a high performance upper stage, the Space Transfer Vehicle, will be studied to initially support unmanned planetary and geosynchronous missions and evolve as required to support human exploration. These studies support NASA's Office of Exploration.

These studies and activities will support national requirements as they are defined. We will continue to work closely with the DOD to define national needs and options to support requirements as they emerge.

We also continue to enhance the cost effectiveness, mission success, and human safety of manned flight through the improvement of operations support systems. The advanced operations effectiveness initiative begun this year emphasizes high leverage expert and autonomous systems technologies in the flight program environment. Near-term efforts focus on ground and flight operations for current systems with longer-term emphasis on improving future transportation requirements and support system operations.

Understanding of the orbital debris environment is another study area to improve in-space safety. Orbital debris studies are continuing to define the environment and its trends, assess the potential damage effects, and evaluate protection concepts. Emphasis is focused at Space Station Freedom altitude.

This past year NASA prepared and submitted the results of a comprehensive study entitled "Satellite Servicing: A NASA Report to Congress." NASA has subsequently established an On-Orbit Servicing Steering Committee to focus activities and to develop a coordinated approach. Ongoing systems studies are oriented toward enhancing on-orbit servicing utilizing Shuttle capabilities and to ensure compatibilty with Space Station Freedom and OMV.

Advanced Launch System

The DOD/NASA report submitted to Congress on January 5, 1988, set forth the ALS program as a joint DOD/NASA program for which DOD has primary funding responsibility. NASA has the funding responsibility to satisfy unique civil requirements not addressed by the ALS baseline program.

In FY 1989, $96.5 million was made available to NASA from DOD to fund the NASA-directed ALS propulsion effort. Of this amount, $74.9 million went to Capability Development, $15.0 million went to Construction of Facilities, and $6.6 million went to Research and Program Management. Our ALS efforts are focused toward demonstrating the performance and operating capabilities of critical propulsion system components prior to committing to final design for the flight hardware development program. Liquid propellant engine and SRB components and subsystems are the focus of this activity. The FY 1990 funding for the Propulsion Advanced Development Program within the DOD budget request has not yet been determined.

NASA is requesting $5 million in FY 1990 to address unique civil requirements which build upon the ALS. The ALS/civil studies initiated this year are refining the definition of mission requirements and civil program requirements. Inherent is a series of tradeoffs to determine the most effective means of providing services to nonstandard spacecraft and payloads.

Tethered Satellite System

For FY 1990, $19.9 million is requested for development to conduct space experiments at distances up to 100 kilometers from the Shuttle. TSS is a joint U.S./Italian cooperative effort established in March 1984 for conducting upper atmosphere and ionosphere experiments. The U.S. is responsible for overall program management, systems engineering and integration, plus orbiter integration, ground and flight operations, development of the deployment mechanism, and non-European science instruments. Italy is responsible for satellite design and development, the European instruments, and integration of science instruments into the satellite.

In FY 1989 subsystem hardware will be completed and system qualification will begin. In FY 1990 TSS qualification will be completed, and flight hardware is scheduled for delivery to KSC. The first Tether mission is scheduled in early calendar year 1991.

Orbital Maneuvering Vehicle

The OMV request for FY 1990 is $107.0 million. A small "space tug," OMV will conduct orbital operations beyond the practical operational range of the Shuttle. Through direct man-in-the-loop control, the OMV will be able to deliver, maneuver, and retrieve satellites at altitudes as high as 1,200 nautical miles above the Space Shuttle. It will reboost satellites to their original operating altitudes, and safely deorbit satellites which have completed their missions. It will retrieve satellites, carry them to the Shuttle for repair or refuel them on Space Station Freedom, and return them to their operating orbits.

FY 1989 resources are continuing the OMV design and development. We are studying OMV compatibility with Space Station Freedom and ELV requirements.

FY 1990 funds will support the continued OMV design, development and testing, and the production of one flight unit. The OMV first flight is scheduled for November 1993.

CONCLUSION

Mr. Chairman, the OSF program is extremely complex and very interrelated to all NASA's efforts in space. It is a tightly crafted, balanced program that will minimally sustain an integrated set of essential activities. The agency's vision, of expanding the frontiers of discovery, understanding, technology, and human experience, provides a broad charter for all our activities.

We simply cannot realize the many benefits of space, unless we are continually and reliably able to get there and operate there. The Fiscal Year 1990 budget request for the OSF before you is on the critical pathway to the success of our mission. I respectfully urge your approval of these funds so that our progress can continue.

Mr. Chairman, I would be pleased to try to respond to any questions you may have concerning this important national program.

Mr. NELSON. I want to turn to our Members. Admiral Truly you were out of the room when I was complimenting you earlier that it would be nice if you can get the Shuttle off on the morning of the 9th or the 10th so that you can be back in Washington and receive your trophy that you so much deserve, along with your team of Center Directors in returning America to space flight, and we compliment you and we are delighted for you that you are going to get this recognition and just hope that you are able to revel in the glory by actually being at the dinner so that you can get your due recognition. But if you are not, you certainly have the admiration of this Committee and we appreciate it.

Admiral TRULY. Thank you, Mr. Chairman.

Mr. NELSON. Before I turn to Mr. Rohrabacher, amplify for the Committee what you said about a smaller people mover completed by smart ELV's, and I take it that you're talking about basically the Soviet model where they have the progress vehicle that can go and be unmanned to their space station and they are developing some kind of little space plane that will get four or five cosmonauts in and around. Is that what you're talking about as a substitute later on for the Space Shuttle?

Admiral TRULY. What I was referring to was—well, first let me go back and remind us about the Shuttle. The Shuttle does many things, and I think it does them all well.

One of the things it does is carry heavy cargo. The Space Shuttle is a heavylift vehicle today. It is the most capable launch vehicle that this country owns. It is the backbone of our fleet, but it carries more than people. What I was referring to in the sense of looking to the future is that one option, and I'm not saying that it's the right option, but it is one that we are looking at, is that we would go to a smaller vehicle to carry men and women into space and design it for whatever the requirement was that we see for the future in the next century and not require that vehicle to also be a cargo vehicle.

If you did that, however, since the Shuttle now provides that capability, you would have to match conceptually such a system with Expendable Launch Vehicles that are based on new technologies such as the Advanced Launch System hopes to develop and plans to develop. So the ELVs are going to have to be smarter than they used to. We would have to use them to rendezvous and go to the space station, for example, safely. So you couldn't set on on that path without an enormous cost without making it a complementary path of a smaller people carrier and smarter Expendables.

The Russian space plane is a possibility. It's a lifting body. As you know, United States tested aerodynamic lifting bodies back in the 1960's out at Edwards Air Force Base. The Soviet space plane is a lifting body, but there are other ways you could do it. There is nothing wrong that I see in going back and using a winged vehicle or a lifting body or a blunt shape like Gemini or Apollo. The main question is defining what the job is and then looking at all these costs.

My only point in bringing it up is we are thinking about it, and I believe in the first half of the 1990's the Congress, the President and NASA is going to have to debate these issues because if we don't extend the life of the Shuttle, sooner or later the vehicles are going to have to be replaced.

Mr. NELSON. Does the National Aerospace Plane fit into all of this mix?

Admiral TRULY. I think a follow-on perhaps might, but the National Aerospace Plane is a technology. It is designated the X-30, like the X-15, et cetera, and by its very nature it's experimental.

The Shuttle is a workhorse, and whatever we are going to have to replace it with is going to have to be a workhorse, whether it's single vehicle or the Shuttle itself or a combination.

Mr. NELSON. Mr. Rohrabacher.

Mr. ROHRABACHER. How long will the Shuttle be a workhorse?

Admiral TRULY. I believe that the Shuttle will be certainly around until the year 2005 or the year 2010, and I also believe that if we chose to evolve it that it might be around longer than that.

I might ask Arnie Aldrich to make a comment, too.

Mr. ALDRICH. I would agree with that answer. I think it can be sustained as long as it serves our needs, and in its current form 2005 and 2010 is very likely and probably necessary.

Mr. ROHRABACHER. With that time frame, and right now of course we have a lot of research going on with the National Aerospace Plane, but do you believe that the National Aerospace Plane will at some point develop this concept to the point that it takes over some of the workload of the Shuttle? Is that something that might emerge from this research project?

Admiral TRULY. The National Aerospace Plane is a program that is not one of my programs. So I'm not that familiar with it. I do know, however, just from my experience and what I know about it though that it's a very, very challenging technological demonstration. It involves quite a leap in a number of systems and materials and engine development, and also in some of the mundane things like landing gear seals and main landing gear designs and so forth because, as you know, the underside of that vehicle will see very high temperatures during re-entry.

So I'm afraid that I can't confidently predict where it would fit in all this. We within the Office of Space Flight, our main objective now of course is to make sure that we safely keep the Shuttle system in operation and match it with our mixed fleet. So these advanced studies that I was talking about are really well into the future.

Mr. ROHRABACHER. Well, when you say the Shuttle might be around as long as 2010, what you are really saying is that for 20 years we are going to have the Shuttle around working for us. Do you think it's likely that new technology is going to be developed in these 20 years so that we might have whole new options in 20 years?

Admiral TRULY. We may very well, and I certainly hope that we do. For example, the Shuttle was initially approved about 1970.

Mr. ALDRICH. Well, the technology was worked on in the late 1960's and it was approved in the very early 1970's, but today I think it is still the most advanced vehicle that is actually flying in certainly many respects.

Admiral TRULY. The only point I was going to make is in the year 2005, which I said 2005 to 2010 was about how long I think we can count on the Shuttle in its present form, that's 40-year-old technology. So now is the time to think about the technology for a future vehicle and we can't put off the decisions too many more years.

Mr. ROHRABACHER. I'm new to this Committee, so again I'm going to excuse myself if I'm asking naive questions. What is the cost factor there of leaving the Shuttle off and making this an ELV? Is this a very cost-effective way of putting things into space or are there other rockets that might be more cost effective?

Admiral TRULY. You're talking about what I was mentioning earlier about the Shuttle–C, taking this vehicle and——

Mr. ROHRABACHER. And that's unmanned; is that right?

Admiral TRULY. Yes. We estimate the development costs of a Shuttle-C to be between a billion and a billion and a half total development costs over all the years of development.

Mr. ROHRABACHER. What about the costs, what would you be projecting in terms of that cost as compared to just developing a big rocket that could put up the same amount of weight in end costs?

Admiral TRULY. It would take several times that amount of money to develop the engines, the solid rocket motors, the tanks, the pads and the ground facilities that with the Shuttle-C we have. The reason that it's so inexpensive, even though let me not say that a billion dollars is an inexpensive amount of money, and I'm not just throwing it around, but the reason that the cost is so low is simply because we use so much of what we have.

Mr. ROHRABACHER. Well, with the Shuttle-C as developed as you would foresee it, would there be recoverable parts? Again this may be a naive question since I'm new to this Committee.

Admiral TRULY. No, it's not at all. Initially the solid rocket motors would be recovered just as we recover them today in the Space Shuttle flights, and we would reuse them. Beyond that, in Shuttle-C we would initially not plan on recovering any portion of the hardware, although if you develop the Shuttle-C you probably would evolve even in the future so that you had a re-entry pod that would return the main engines in an aerodynamic fashion so that you could later use it, but the costs that I mentioned in the Shuttle-C in its initial years would be expendable, except for the solid rocket motors.

Mr. ROHRABACHER. I'm sorry, I don't know how much time I'm supposed to take up here, but you would foresee then if we were developing an unmanned craft to get things cheaply into orbit that the Shuttle-C might be developed to the point where it was actually the cheapest way of getting things into orbit in an unmanned fashion, heavy payloads?

Admiral TRULY. Shuttle-C would be the only way to get payloads into orbit that weigh as much as it's capability is. In other words, we have no capability in the United States today to get payloads into orbit on a single launch greater than about 55,000 pounds in a Space Shuttle and after the solid rocket motors come along, around 65,000 pounds. So not only would it be inexpensive, but it would be infinitely cheaper than any other vehicle since there is no other one that could carry those payloads.

Mr. ROHRABACHER. I'm talking about in terms of projecting into the future just in terms of the basic concept itself using the Shuttle-C versus building some new, what we call the big dumb booster, which would then enable people to put things as cheaply as possible into orbit and perhaps opening it up more to the commercial sector when you have something that is a cheaper method of getting things into orbit.

Admiral **Truly**. I think the real economies in smaller ELVs and not in heavylift boosters. You've got to also appreciate that if you are putting something up that is that heavy, for example, an element of the space station or a large planetary that is headed out into the universe, you're talking about a very, very precious and expensive payload. So, although I didn't say it this morning, the thing that you really want in launch vehicles is high reliability. Nothing costs more in the launch vehicle business than low reliability, and therefore the Shuttle-C I would argue for heavylift vehicles would be most important because it would bring with it the reliability that we have poured our resources into in the Shuttle, the solid rocket motors, the main engines and the external tank. So it's an attractive vehicle if the nation believes that we have a requirement for it. There is not a new start in the fiscal year 1990 budget that is before you today for Shuttle-C. We are finishing the definition studies. So it will be a debate I believe certainly within NASA in the fiscal year 1991 submission.

Mr. **Rohrabacher**. And the fact that some of the elements would actually be recoverable actually might make it much more cost effective than some of the other alternatives that we're looking at. I don't know if any other plans have recoverable aspects.

Admiral **Truly**. I know of no other Expendable Launch Vehicles that has any plans to recover elements of it. Again, however, in the longer term when we develop the next family of vehicles in the Advanced Launch System that I mentioned, you would have the possibility there to look at recovery similar to what we do on the solid rocket motors in the Shuttle program. But today I know of no other system that does recover and reuse its hardware.

Mr. **Rohrabacher**. Thank you.

Mr. **Nelson**. When will the decision be made to pursue the Shuttle-C?

Admiral **Truly**. As I understand the schedule, it would be debated as a potential new start in the fiscal year 1991 budget.

[The information follows:]

Shuttle-C, identified as a potential FY 1991 new start, is currently in preliminary design with three study contracts in progress through September 1989. A common reference configuration has been selected with trade studies underway to optimize and refine the concept. With an approved FY 1991 new start, Shuttle-C could be available in late CY 1994 for flight test.

Mr. **Nelson**. That would be next year's budget, and do you have a ball park as to how much money would be required in '91?

Admiral **Truly**. No, I don't, Mr. Chairman, have it at my fingertips, but as we continue this definition, I'm sure it's available and I could provide it for the record.

Mr. **Nelson**. I want to remind you, you are due a report to us due last January the 15th. On the Commercial Space Launch Act there was a report due by NASA on launch vehicle research and development. NASA is under the law to design a program for support of research in the launch systems component technologies. That was due January the 15th, and we haven't seen the report.

Admiral TRULY. Mr. Chairman, thank you for reminding me of that. I thought I was tracking several reports that we owe you in the last several weeks. I'm not sure of the status of that, but I will check on it—it is on the way to you—and not only light a fire under that, but I will also let you know how we stand on it.

Mr. NELSON. Mr. Smith of New Hampshire.

Mr. Robert Smith of New Hampshire: Mr. Chairman, just a couple of points.

We are pretty hard on these guys here, and I would like to defend them just for a minute, and I would like for perhaps your comment on this as well, and I have been as hard on them as you have. So I'm criticizing myself.

For example, in the case of Mr. Fisk, and I know the same is with Admiral Truly, I know how Mr. Fisk feels about space science and his objectives, but maybe we have the wrong people before us.

If you look at the numbers, and you take space science, the requests were there for Gravity Probe-B and the requests were there for the ACTS program. If you look over in Admiral Truly domain, it's the same thing, $119 million cut from the Shuttle production, $43.7 million cut by OMB on the Operations budget and the Expendable Launch, $128.5 million cut.

It's obvious that these folks at NASA are making the presentations to OMB along the lines that I think this Committee would be supportive of, and obviously OMB is not supporting that. We can't expect them necessarily to—well, I don't know what we expect them to do here. Maybe that's the question that I'm asking you, what we expect them to respond to.

I guess the impression that they are making a good strong pitch for this and they are losing. That can happen to us on the floor of the House, as you know, with our own budget. So I just want to make that comment editorially, and perhaps after the hearing, if you wish, you might respond to it perhaps just in terms of process whether we might be able to be a little more productive than just being critical of NASA, which I think we all have been, and pretty harshly so in the last two or three days.

But given that comment, and you don't have to comment back unless you wish to comment, either one of you, and you may if you wish, but I don't blame you. [Laughter.]

I just want to zero in on one very specific aspect that I'm kind of interested in, and then turn it over to whoever is next. In this mixed fleet policy that we have come up with mostly after the Shuttle disaster, but certainly it was brought about and being worked on prior to that, and certainly it was really highlighted after the Shuttle disaster, have we set some specific guidelines as to just what payloads are going to be put up with man presence and what ones are going to be put up on ELVs? Have we really come out with specific direct guidelines on this?

Admiral TRULY. At the time of the Challenger and the Titan 34-D accidents, we were faced with such a huge payload backlog over the years and, as you know, in the year or so after that that the mixed fleet policy and funding and so forth was debated and put into the budget and argued for.

We did make an assessment of the Shuttle manifest and found, frankly to our surprise, to my surprise, that there was a fairly small percentage of the total number of missions that really didn't either require the Shuttle itself because of its capability or man's intervention. So the initial potential list was really only about 15 percent of the total that was backlogged over the original Shuttle manifest.

We then went to that 15 percent on a satellite-by-satellite basis, and at least in these early years we have done that each on an individual basis. Essentially what Joe Mahon here and I have tried to do is where there was a vehicle available and where we could avoid lengthy delays and where in working with the Congress we could afford to buy a vehicle, we have moved ~~the~~ maximum number that we could, considering those things from the ELV's.

You asked if there are specific guidelines. I am setting up, which I will chair, a Flight Assignments Board so that when new missions come along they can be addressed formally with myself and representatives from Shuttle and representatives from ELVs and also the other Associate Administrators and more formalize that process.

Mr. **SMITH** of New Hampshire. I'm not really up to speed on the Shuttle-C. The Shuttle-C is strictly cargo and no man?

Admiral **TRULY**. Yes, that's correct.

Mr. **SMITH** of New Hampshire. And you can bring that back? It's not an ELV, and you can bring it back?

Admiral **TRULY**. It would be an ELV except for the recovery of the solid rocket motors. Essentially the advantage of the Shuttle-C would be to lift very heavy cargo. It's a capability that the Soviet Union, as you know, has today with its Energia. It's a capability that has been much debated in this country. You can certainly, as an example, and we plan to, package this space station so that it can be launched entirely on Space Shuttles.

Mr. **SMITH** of New Hampshire. It's a bit of a misnomer to call it a Shuttle, isn't it?

Admiral **TRULY**. Well, we did talk about what to call it, but when I think of the part of the Shuttle that orbits, that's the Orbiter. When I think of Shuttle, it's a far bigger system than the Orbiter.

Mr. **SMITH** of New Hampshire. I think of it as the Orbiter is orbiting and the Shuttle coming back. Maybe it's just semantics.

Admiral **TRULY**. Well, at any rate, we chose, right or wrong, we chose Shuttle-C for shuttle cargo as the nickname of this project so far.

Mr. **SMITH** of New Hampshire. One final point. On your '89 manifest, launch manifest you have tracking and data relay satellites that are going to be launched from the Shuttle, as I understand it in fiscal year 1993 and 1994. Why do you need to launch tracking and data relay satellites from a manned shuttle? I don't understand why they can't be launched from an ELV.

Admiral **TRULY**. That is specifically one of the vehicles that we did debate. The tracking data and relay satellite that's on the 1993 manifest, or whatever year, is essentially identical to the tracking data relay satellite that we launched on STS 26 and we are going to launch on this next vehicle here in a couple of weeks. So all of the hardware interfaces, the design of the spacecraft and the procedures and so forth are not only designed properly but flight proven.

Within OSF we did look at what would be required to modify the TDRS satellite, the tracking data and relay satellite to a Titan III I believe, was it not, Joe?

Mr. MAHON. Yes.

Admiral TRULY. We did identify that that was a feasible thing to do, but economically it was a poor choice because we had to take a proven vehicle and interface and change it for a Titan III, and we had to go buy the Titan III.

Mr. SMITH of New Hampshire. So you have or you have not ruled it out from using an ELV?

Admiral TRULY. We have technically not ruled it out, but NASA has made the decision today to launch those follow-on missions on the Shuttle.

Joe, would you like to comment on that.

Mr. MAHON. Yes. That particular mission that is being discussed, the one that was scheduled for Titan III, happens to be a backup mission for the TDRS mission. With the success of the one in orbit and the first one that had been in orbit, their system has been established. So the need for a backup is lessened, and with the next launch coming up on schedule, it has a TDRS in it also, and the system would be pretty well established such that you would not need that additional flight in that time frame, and that was taking an expenditure of money that the agency decided was not necessary at this time.

The follow-on TDRS Spacecraft, the next lot that they are buying, are being studied now for mutual compatibility. It can be launched either by an ELV or by the Space Shuttle, and as the program progresses they will make the design decision through their Phase A and Phase B studies as to which selection, which method of transportation will be made.

Mr. SMITH of New Hampshire. One final point. The so-called critical items list, if you were to make up a list of 10 critical items that would be required to be launched from a manned vehicle, would that be on your top 10 list?

Admiral TRULY. The answer to that is no. The tracking data relay satellite, considering all the things we have said here today, technically can be launched on an ELV. So in that sense we could pay the money and put it on an ELV, but all things considered, the agency decided to continue to manifest it on the Shuttle.

Mr. SMITH of New Hampshire. I just want to be clear though, and I'm not accusing you of this, but I don't want to pit safety versus budgetary matters here. Now you can say to me unequivocally that you are not doing that in this particular case; is that correct?

Admiral TRULY. Yes, that's true.

I would like to make one point though. Frankly, the Space Shuttle is the most reliable launch vehicle that the country presently has, and we do have satellites that approach the cost of the Shuttle. Frankly, at those expenditures it seems to me that there is an argument to fly some of these on the Shuttle even though there are cases where you could put them on ELVs.

At any rate, whether that is true or not, the agency made the decision that we could keep it on.

Mr. **Smith** of New Hampshire. It probably would not be the only payload on the Shuttle.

Admiral **Truly**. In the case of the Titan III it's so heavy that other than some minor other—there are a very few thousand pounds that are available for secondary experiments and so forth, but as far as the major mission, it would be the purpose for the flight as it was on STS–26 and it is on the one that is sitting on the pad today.

Mr. **Smith** of New Hampshire. Thank you.

Thank you, Mr. Chairman.

Mr. **Nelson**. We are just simply running out of time and I need to keep things going.

With regard to your question about Shuttle-C, if you'll look at that little handout, basically what you do is you take the existing stack, you remove the orbiter here, and in its place you put a vehicle, which is basically a big cargo bay with the engine sticking out of the tail. You can either put two or three engines on there. Their first design is that instead of it coming back and saving those engines, you would expend once it has deployed its payload on orbit, and it would then re-enter and burn up. So you would lose those engines.

A different design could be achieved in the future where you could have a returnable cargo vehicle that would come back and actually land, but would not be manned.

Mr. **Rohrabacher**. To be cost effective, that would be the way to do it.

Mr. **Nelson**. That's right, and you would have to work that out on a mathematical calculation.

So what it would do is, and what Dick is saying is it keeps the proven technology of the tank, the solids, the engines and what you stick into place is a big shroud that covers the payload so that you don't take the orbiter, which is the manned vehicle, into space. Therefore, you can still use your existing launch facility, your existing processing facilities, your existing processing facilities and you've got a proven technology that allows you to get 100,000 to 150,000 pounds to orbit.

Now one of the questions we want to continually ask is what he said early on, we need that capability, and particularly with the slow-down of the Advanced Launch System in the Air Force maybe we need this capability of heavylift, but the question is do we need the smaller lift capability of smart ELVs. That is what the Soviets have right now that can come to a space station and rendezvous.

And as part and parcel of that, by the way, how about a lifeboat, a rescue vehicle that needs to be attached to that space station. I mean it's not a Space Shuttle. It would be something that in case an emergency occurred that the crew could get into and come home if we couldn't get a Shuttle to get up there to get to them.

So these are some of the questions.

Let me just make a quick comment, Mr. Smith, with regard to your opening comment.

This Committee is going to absolutely require that NASA hold itself accountable under the Constitution to the Congress. Part of the reason, and not by any means the whole reason, that we got into the trouble with Challenger that we did, is that for years with NASA's success it could do no wrong and arrogance crept in and it did not hold itself accountable to others. As long as I'm Chairman, we are *going to try to hold* NASA accountable.

Now the question is where NASA has made a proper request, then the duty of this Committee is to sort through that request and understand that clearly through cooperation and not obfuscation by NASA, and where they have not made a proper request, for us to zero in on that.

And the Observer line item is a case where they have not made a proper request. It was an agreement that this is what it was going to be and it's not here. We are going to get it out in the open and we are going to try to find out why.

So that's my response to this. We are not beating up on Admiral Truly or Dr. Fisk. I mean, first of all, this is a love feast compared to yesterday. [Laughter.]

But we really weren't beating up on yesterday's witness because, I mean all this terminology that was coming out, and Mr. Rohrabacher picked up on this about these are commercialization of space, and it's not. I mean that is not what Bob Walker lives and breathes on, which is the true commercialization of space.

What that was, was a term inartfully used to say that it was taking an item off the budget. That's what it was.

Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman. I'll try to be short.

Since the Challenger accident we spent nearly three years before we were back in space in upgrading and improving and correcting and re-evaluating our communications systems and our entire structure of space travel, manned space travel, and since then we have now launched two manned vehicles and we are back in space.

I'm not sure this Committee has had a good opportunity to hear if in fact we are realizing the changes in the system that we obviously were looking for during those three years of shutdown. And now that we've got two launches behind us, is it clear that we have made the necessary corrections to avoid a repeat of Challenger? Are the communications systems operable now different than they were before and if we launched today under similar circumstances than the Challenger was launched, weather-wise and all other technical and personnel and all other circumstances, would we have a different outcome today if Challenger was launched because of the changes?

Admiral TRULY. Mr. Packard, I would like to comment on that very briefly, and then I would also like to ask Arnie Aldrich to comment because Mr. Aldrich has been down in the launch control center for many more launches than I have.

Let me tell you my assessment is, first of all, that we cannot make it risk free. We don't print enough money to take risk out of a space flight. The only way to take risk out of a space flight is to decide you want to stay here on the earth, and that's not our business.

However, we have a system that is operating today, from my point of view, that is better than any time we have seen it at

NASA, and I'm talking about Centers working together, Headquarters working with Centers.

These first two flights, incidentally, the STS-26 and STS-27, I was down in the launch control center sitting next to Arnie, and those were not easy flights to get airborne. We dealt with difficult technical issues on upper-level winds and all the things to go into that and the system worked.

We have a Shuttle program organization that you are familiar with that goes top to bottom and does not, even though it is integrated into the Centers, it reports to Arnie Aldrich and he reports to me as the Center Directors do.

So I am satisfied that we have a system in place, and I think we have accomplished what we set out to do, but we had better not get complacent.

Mr. PACKARD. In brief, that's what I wanted to hear from you, Mr. Aldrich, is what are we doing differently than we did before the Challenger accident?

Mr. ALDRICH. It's hard for me to talk on this subject without giving a long answer, and I'll try to summarize.

One of the most important aspects of our new organization is the up-down communications in the program structure, and a very key element of that that did not exist in the pre-Challenger time frame is the office that I have permanent full time in place in Florida under Bob Crippon that manages the operations day to day leading up to the launches and then makes the launch commit at that time. That's a new augmentation that has been very important and I think has been extremely valuable in understanding and communicating daily on these launches.

A second very important addition is the organization that Mr. George Rodney runs here at NASA Headquarters, and safety, reliability and quality assurance that Associate Administrator, Dr. Fletcher, and the organization that he has in place in the projects around the NASA structure and at the NASA Centers and how active and focused and communicative they are in parallel with our project plan. Those two are very specific changes, they are very important and they are visible daily and they are very strong.

In terms of the hardware, I believe we have addressed very thoroughly and very carefully changes that will improve and add margin to the Shuttle system, and we have implemented those and we have a forward looking program of continuing to bring additional improvements into the program even beyond where we were when we felt very comfortable that we had addressed the critical things well to return the Shuttle to flight.

Admiral TRULY. Mr. Packard, there is one other thing that I would like to say on this subject. Early I said that I had never seen a tighter budget environment than we are operating in today, and I meant that. But the line has been drawn in the sand about the underpinnings that we have put into the Shuttle program, the ground test program, the engine test program, and we did go through our budget and it did hurt in line item after line item in looking for dollars as we got down to the levels that this FY-90 submission is. We didn't go into that underpinning. We took out content where we could do it, and there are numbers of examples of that, but when it came to safety, we didn't do that.

Mr. NELSON. Mr. Schiff.

Mr. SCHIFF. Thank you, Mr. Chairman.

Admiral Truly, as another Member of the Committee, I would like to ask something that I feel certain has been covered before, but I need to ask.

In November of 1986 I visited Vandenberg Air Force Base on a reserved tour of duty. We were shown the launch pad there and the discussions and explanations were that the Shuttle would be launched from there, and somehow, if I'm understanding correctly, in the intervening time between November of 1986 and the present time Vandenberg seems to have gone away as a Shuttle launch site, if I'm correct. Am I correct about that, or do I have that all wrong?

Admiral TRULY. Yes. Space Launch Complex 6, or slick six as they call it out at Vandenberg, the decision has been made to mothball it, the decision on the part of the Air Force facility, because it is an Air Force facility, has been made to mothball it. It would take about a minimum of, from the estimates that I've heard, of about four years and several hundreds of millions of dollars to get it back so that we could fly manned flights off of it, which is a very unfortunate situation I think because I really believe in the longer term that American men and women should fly over our poles as well as our equator.

Mr. SCHIFF. Which was the purpose I was told.

Admiral TRULY. Which was the purpose of the inclination because of the range safety and the fact that you can go due south out of Vandenberg and end up in polar orbit.

Within our program we have taken advantage, however, of this unfortunate situation and have gotten a lot of cooperation, I must tell you, from the U.S. Air Force in retrieving a lot of the equipment and ground support equipment and so forth, and that's part of the thing that Arnie has applied down at the Cape in cost avoidance, you know, for that. But the answer to your question is that it's in mothballs and nothing has been done to preclude it from later being brought back up.

Mr. SCHIFF. Do you mean that all Vandenberg Air Force Base is in mothballs or just the launch complex?

Admiral TRULY. No, the slick six, or that launch complex only. As a matter of fact, the activity level on the West Coast and the western test range and Vandenberg is very high. There is a new Titan 4 pad out there and they are desirous of having a second Titan 4 pad. But that facility at present, which was ready to fly a Shuttle flight in 1986, it's first West Coast flight, is in mothballs.

Mr. SCHIFF. Could I ask why that decision was made, because it was just built. I mean I say it was still under construction in November of 1986.

Admiral TRULY. Simply dollars. At the time the decision was made on the part of the Air Force to mothball it, they had manned up and they were paying a huge cost in manpower for configuration control and so forth. After the accident it was uncertain as to exactly how long it would take us to get back into flight.

As we did in some of our programs, we took some of our programs down to what I would call rock-bottom levels, and the rock-bottom level for that facility was to put it into mothballs and they chose to do that.

Mr. **Schiff**. In other words, that was a U.S. Air Force decision?

Admiral **Truly**. Yes, it was.

Mr. **Schiff**. Thank you, Mr. Chairman. I have no other questions.

Thank you, Admiral.

Mr. **Mahon**. Could I add one thing just to enlarge on that, if you don't mind?

Mr. **Nelson**. Mr. Mahon, we've got to move on.

Mr. **Mahon**. OK.

Mr. **Nelson**. We've got to move on.

Mr. Nagle.

Mr. **Nagle**. Admiral, let me start with the infamous CDSF. Is that in this budget?

Admiral **Truly**. No, there are no dollars in the FY-90 budget for CDSF. I believe that's true. There may be a very small amount of study money.

Mr. **Nagle**. How about $5 million?

Admiral **Truly**. Maybe $5 million.

Mr. **Nagle**. What's in for 1991?

Admiral **Truly**. I don't remember that figure. I can either look it up or get it for you for the record.

Mr. **Nagle**. How about 1992?

Admiral **Truly**. I'm sorry?

Mr. **Nagle**. 1992.

Admiral **Truly**. Let me look at one piece of paper real quick and I'll tell you.

Mr. **Nagle**. Sure.

Admiral **Truly**. In the runout of the 1990 budget, the first funding is in 1992, which is $20 million.

Mr. **Nagle**. And that's for the initial lease payment?

Admiral **Truly**. The monies that are in those out-years are for lease payments.

Mr. **Nagle**. And in 1993 it's launched?

Admiral **Truly**. Well, since the program isn't defined, and we don't have the studies into NASA and we are obligated to bring them to the Congress, we don't have it manifested.

Mr. **Nagle**. Then why are we paying a $20 million initial lease payment in 1992 on the budget runout? I mean that's just a small amount, too.

Admiral **Truly**. No, we wouldn't. If program doesn't become a reality, we wouldn't. That's not a part of the 1990 request, but it's a projection of future years.

Mr. **Nagle**. I think the Congress specifically ordered NASA not to proceed with the CDSF until the completion of studies and until Congress had had a chance to review the studies. There was one by the National Research Council and then there was another.

Admiral **Truly**. Yes, there are two studies that are going on. One is by the NAPA—Public Administration, and one by the National Research Council on requirements, and we are obligated, as I understand it, to complete those studies which will be completed this spring, and we will bring them back to the Congress at that time.

Mr. NAGLE. So in terms of this $5 million request, and I know it's not the largest thing in the NASA budget, but we can hold on that $5 million request until we see the result of those studies. That would be fair, would it not?

Admiral TRULY. The $5 million in the 1990?

Mr. NAGLE. Yes.

Admiral TRULY. Certainly if the CDSF doesn't proceed as a program, we will not need the integration money to define the interfaces with the Shuttle system.

Mr. NAGLE. Now I want to focus on the Shuttle itself, or what I think we term the Orbiter. As I understand it, there are two ongoing bodies that investigate the safety of the NASA program. One is in-house and one is an organization called the ASAP; is that correct?

Admiral TRULY. Those are two of many people that look at the Shuttle program, but in-house we do have, as was mentioned just a minute ago, an independent safety, reliability and quality organization that reports directly to Dr. Fletcher and we work with him. The ASAP I believe is a Congressionally mandated aerospace safety advisory panel, and they do work with us. They have an opened door at our flight readiness reviews, and annually they write a report and submit it to the Congress and to us and we respond to it.

Mr. NAGLE. And then from the original Roger's Commission there was a subcommittee called I believe the Slay Commission that also made recommendations for safety implementation in the post-Challenger environment?

Admiral TRULY. The Slay group was not subservient or a subpart of the Roger's Commission. In the aftermath of the accident we were looked or investigated by the Roger's Commission, the Congress, the Slay group worked with us and there were I think other national research council committees that each wrote a report and we addressed the concerns.

Mr. NAGLE. Now all three groups had some specific recommendations with regard to concerns about the Orbiter itself as opposed to at that time the SRM.

Admiral TRULY. In every case each group did take their deliberations and recommendations into writing and made recommendations that were not limited to the ones you named, but all parts of our operation, the Orbiter, the tank, the ground equipment, the people, everything.

Mr. NAGLE. Now have all of those recommendations been implemented?

Admiral TRULY. We have addressed every single recommendation of every one of those organizations, and in some cases the final implementation was not precisely their recommendation, but in every case I think we satisfied ourselves that we met the intent of it, and in most cases specifically what they recommended.

Mr. NAGLE. Now I'm going to stay just on the Orbiter. As I understand it, a number of these organizations have expressed some concerns about the structural integrity of the Orbiter. That would be fair?

Admiral TRULY. They have, and if I might comment on that.

Mr. NAGLE. Sure.

Admiral TRULY. We have had an ongoing program within the Shuttle program since before the first flight of comparing the specification that the Orbiter was originally built to and the as-built configuration of the hardware to various loads estimates, and a loads estimate is a result of a complicated mathematical analysis of what in general winds or sheers or headwinds, tailwinds, and so forth, would do to a vehicle.

In some cases and in some serious cases in the wing, the tail and parts of the Orbiter, and in some cases even other parts of the vehicle, we have found areas where the structure as built did not meet the original specification. So those are generally referred to as structural deficiencies or inadequacies in the structural design.

So then what we have done is, in order to protect the safety margins that we have in the system, we have limited our capability on launch day by restricting the upper-level winds, as an example, that we are willing to fly in. So rather than bump safety, we have bumped capability, and that generally is referred to as launch probability, in other words, the probability on a given day that you will go out to the pad and be able to get airborne.

Our launch probabilities today on STS-26, 27 and this next flight are less than the .95 that was in the original specification, and that is an engineering judgment we have made within the program.

Mr. NAGLE. I think it's something the Congress should be aware of, that in spite of some specific recommendations of concern over the fuselage, particularly the back part of it, the wing near the fuselage and the tail, some of those repairs were made and some of those repairs were addressed simply by restricting the opportunity of launch.

Admiral TRULY. That is correct, and if I might, I might ask Arnie to elaborate specifically on items like that, like the tail or the wing, if you would like to amplify what I've said.

Mr. ALDRICH. Well, Admiral Truly, following your comments I think they have been very accurate. The Orbiter has had changes in its performance capability based on differences that were found out after it was flown from measurements taken in flight. The environment was different than predicted by a wind tunnel, and therefore the performance of the vehicle was recharacterized in degree, but also a large number of structural changes were made to bring back most of the performance that had been initially intended. Changes have been made significantly to the wings and to the fuselage.

The margins we now fly to are the same as was intended for the original design, but the way we fly the vehicle and the constraints are a balance between performance and the magnitude of the expense and time frame and difficulty it would take to redesign vehicles that now already exist to reach the original full performance with those structural margins.

Mr. NAGLE. We had a conversation yesterday in my office about this, and I requested then and I would like to request now for the Committee if you would send us a list of restrictions or changes in the probability of launch that you've made in light of the recommendations of these various committees.

Admiral TRULY. Yes, and we'll be glad to do that.

[The information to be supplied follows:]

NASA
National Aeronautics and
Space Administration

Washington, D.C.
20546

MAR 10 1989

Reply to Attn of: M

Honorable David R. Nagle
Subcommittee on Space Science and Applications
Committee on Science, Space and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Nagle:

When Mr. Arnold Aldrich, Director of the Space Shuttle program, and I met with you on February 28, and again in the hearing on March 1, 1989, you requested some amplifying information on Space Shuttle structural margins, specifically as they relate to reductions in launch probability. I am enclosing some information on this subject for the orbiter, the external tank, and the solid rocket booster which I hope will be satisfactory. In addition, I am including a few words of background information to help you appreciate the long history of decisions that have led to our present status.

If you have any further questions on this information, or would like to speak to Mr. Aldrich or me again about it, we would be pleased to do so.

Sincerely,

Richard H. Truly

Richard H. Truly
Associate Administrator
for Space Flight

Enclosures

Space Shuttle Structural Margins

- Prior to STS-1 the expected capability of the Space Shuttle system was intended to meet all system performance requirements, including a launch probability of 95%, while still maintaining a structural factor of safety of 1.4 for the Orbiter, Solid Rocket Booster, Space Shuttle Main Engine and the Launch Facilities, and 1.25 for certain very predictable pressure and thrust loads in the External Tank. This was based upon analysis and loads and wind tunnel testing corresponding to an external loads data base, derived by the Shuttle Program, called Integrated Vehicle Baseline Configuration 2(IVBC-2).

- The design of the Orbiter to meet the IVBC-2 loads (while achieving full factor safety and performance requirements) was determined by structural testing and a detailed stress analysis of approximately 60,000 Orbiter parts. This was defined as the Orbiter 5.4 Loads Cycle.

- Analysis of the initial Space Shuttle flights showed significant differences in ascent vehicle aerodynamic loading than had been predicted by the earlier analysis and wind tunnel testing. This partially invalidated the IVBC-2 External Loads data base.

- Consequently, a new Integrated Vehicle Baseline Configuration Load Analysis, IVBC-3, was initiated along with a new Orbiter 6.0 load cycle. In addition, launch and ascent operational placards were established to permit the Shuttle to continue to fly within safe margins, and an extensive flight instrumentation program was initiated to acquire data to provide a better understanding of the ascent aerodynamic loading.

- A full Orbiter load cycle is a multi-year undertaking. Early in the 6.0 Load Cycle a quick look analysis of the Orbiter called Orbiter Capability Assessment-D (OCA-D) indicated that a number of major structural modifications, primarily in the wing and lower fuselage areas, would need to be made if the Orbiter was to deliver adequate lift performance. These modifications were engineered and implemented in the 1984 through 1987 time frame.

- During the same period, the program made a conscious decision that it would not be cost or schedule effective to provide the extensive modifications (particularly to the wings and tail) to completely achieve the full 6.0 Load Cycle IVBC-3 capability. As a result, the OCA-D capability was baselined as the requirement for the wings and some other Orbiter components. This decision, therefore, led to the acceptance of 75% to 85% launch probability. Changes to the ascent trajectory based upon real-time measurement of the winds aloft will markedly improve launch probability. Development of such capability is currently in progress.

- Thus, the Shuttle Program has baselined the requirement for factors of safety of 1.4 for all Shuttle elements (1.25 for portions of the External Tank) against the IVBC-3 6.0 Load Cycle Data Base, with a reduction of the flight envelope to the OCA-D requirements for the Orbiter wing and tail. The following table presents Shuttle structural components which currently do not comply with this combined set of requirements.

- In all cases, placards in addition to IVBC-C/6.0 Loads/OCA-D criteria are employed and honored for all flights to assure no reduction in safety.

I. ORBITER

3 of 30 Major Orbiter Structural Elements Have Negative Margin Components Positive Margins and Factor of Safety 1.4 are Assured by Appropriate Mission Planning and Day of Launch Redline Evaluations

ELEMENT	ASCENT	DESCENT	ACTION PLAN
1) WING			
A) WING TRUSS TUBES WING BOX - 5 GLOVE - 3		-0.01 TO -0.14 (M = 0.80)	• MINOR REDUCTION TO PITCH V-N DIAGRAM SPECIFICATION PROTECTS NEGATIVE MARGINS. PROGRAM APPROVAL IN PROCESS. • STRUCTURAL MODIFICATIONS UNDER CONSIDERATION FOR EXTENDED MODIFICATION PERIOD.
B) WING UPPER COVER STIFFENER	-0.01 TO -0.20 (M = 1.25)		• STRUCTURAL MODIFICATIONS UNDER CONSIDERATION FOR EXTENDED MODIFICATION PERIOD.
C) $X_0$1307 SPAR INTERFACE	-0.01 TO -0.27 (M = 1.25)		• STRUCTURAL MODIFICATIONS UNDER CONSIDERATION FOR EXTENDED MODIFICATION PERIOD.
2) AFT FUSELAGE			
A) OMS DECK FRAMES	-0.26 (M = 1.05)		• STRUCTURAL MODIFICATION KITS AVAILABLE. INSTALLATION SCHEDULED DURING EXTENDED MODIFICATION PERIOD.
3) VERTICAL TAIL			
A) AFT SPAR WEB FASTENER BEARING	-0.24 (M = 1.25)		• CHANGES TO TAIL STIFFNESS MODEL ARE BEING IMPLEMENTED. WIND GUST CRITERIA CURRENTLY UNDER REVIEW. EXPECTED TO RESULT IN SIGNIFICANT RELIEF TO NEGATIVE MARGINS OF SAFETY WHICH MAY FULLY COMPLY WITH OR EXCEED OCA-D. • SELECTIVE MODIFICATIONS HAVE BEEN DEFINED BUT WOULD HAVE LARGE COST AND VEHICLE IMPACTS TO IMPLEMENT.
B) AFT SPAR CAP CRIPPLING	-0.23 (M = 1.25)		
C) TAIL/FUSELAGE AFT INTERFACE LUGS	-0.25 (M = 1.25)		
D) TAIL COVER PANELS	-0.36 (M = 1.25)		
E) TAIL JOINT LUGS	-0.31 (M = 1.25)		
F) TAIL ROOT RIB	-0.31 (M = 1.25)		

II. SRB / ET ATTACHMENTS

ELEMENT	ASCENT	DESCENT	ACTION PLAN
AFT ATTACH FITTING	1.36		• APPLICABLE ONLY TO WESTERN TEST RANGE. LOAD INDICATOR UTILIZATION ASSURES >1.40 FACTOR OF SAFETY FOR EASTERN TEST RANGE LAUNCHES
FORWARD ATTACH BOLT	1.34		• 1.35 FACTOR OF SAFETY BASELINED AS REQUIREMENT IN 07700 VOLUME X. RATIONALE INCLUDES FACT OF UTILIZING 104% SSME MAX POWER LEVEL. (1.34 WAS BASED UPON 109% SSME POWER LEVEL)

III. SRB

ELEMENT	ASCENT	DESCENT	ACTION PLAN
AFT SKIRT	1.28 (LIFTOFF)		• CONTROLLED TO ACCEPTABLE LEVELS BY LAUNCH WIND PLACARDS AND STACKING TECHNIQUES. • DESIGN MODIFICATIONS WHICH MAY PROVIDE ADDITIONAL RELIEF ARE UNDER DEVELOPMENT. • MORE SIGNIFICANT SKIRT ALTERNATE DESIGN OPTIONS UNDER STUDY IN CONJUNCTION WITH ASRM.

Mr. NAGLE. Are you telling us that all of the changes that have been recommended by these various committees, with which NASA concurred, have either been implemented by replacement or repair or change or the launch window has been restricted to stay inside the margins?

Admiral TRULY. Yes. We have addressed each one, and either by making the change or restricting some part of our operation like, for example, winds, and a good specific that has been discussed with the Committee is the problems we've had on the aft skirt of the solid rocket boosters, and we have beefed up the aft skirt, but we have not totally redesigned it in order to get flying again. However we have protected the vehicle by lowering the winds in a certain quadrant, it's from the south, to a certain level because that load criteria is worse right at liftoff. So the answer to your question is yes, we have either protected the vehicle or made the change.

Mr. NAGLE. So what we are faced with on the Committee then, if I understand it, is that we have less opportunities to fly because of the diminishment of the margins in which we will go ahead and launch a vehicle.

Admiral TRULY. That is correct, and you saw that on STS-27 as a matter of fact. We cancelled the first day because of upper-level winds, and that was a case where had we decided to keep the vehicle down for another period of time and spend the money and beef it up, we could have flown that day.

Mr. NAGLE. Have you requested in this year's budget any monies to work to expand that probability of launch window by further changes in the Orbiter itself?

Mr. ALDRICH. We have requested in this year's budget specific dollars for additional structural changes. However, as part of this budget and in the next several years we continue the engineering work and the analysis to round out our complete knowledge of the vehicle with engineering and math modeling and also additional flight instrumentation which will come off the future flights of both Atlantis and Columbia.

So, yes, there is money. It's not directly related to a structural change that I could describe today, but it does relate directly to finalizing our total data base on this subject.

Mr. NAGLE. Now is it a fact that in light of the agency decision, the Administration decision to pursue the ASRM, the Advanced Solid Rocket Motor, that we do not at this point have any studies indicating whether or not this will cause further problems on the structure of the Orbiter itself?

Admiral TRULY. I'm not sure I understood the question, but let me just say we do have extensive studies, and we started by restricting the Advanced Solid Rocket Motor to live within the interface specifications that we already had where it interfaces to the external tank and to the integrated vehicle. So the very design of the ASRM is required to fit those interfaces.

Mr. NAGLE. Well, I understand the ASAP is going to issue a report this month that will indicate that it's questionable whether the ASRM will offer a measure of increase in safety and reliability for the cost of the thing. Is there at least one agency that questions whether or not ASRM is going to——

Admiral **Truly**. They have not issued their report. So I would prefer to wait until they do, but there has been debate as to whether the Advanced Solid Rocket Motor is the prudent choice and we have debated it internally within NASA, not only myself and Arnie, but our Management Council made up of our Center Directors at Marshall, Kennedy, Stennis and Johnson, and there are those who believe that we could apply our money to other fixes in other ways that would increase safety better.

I would make two comments. One is that that is a judgment call, and it is our judgment within NASA management that the ASRM is a very good investment. We are going to be flying the Space Shuttle, as we said earlier in the hearing, probably out to the year 2010. We can make a better solid rocket motor than the one we're flying on the Shuttle today, but we can't make it without an investment in a facility to do that. So we wanted to do it.

The second point I would make is we have a goal of a 12,000 pound performance increase from the ASRM, and we believe that we can meet that goal, but even if we miss it and say, for example, can only deliver 10,000 pounds on 10 flights or six Shuttle flights plus 10,000 pounds, that's an extra Shuttle flight. It's like a 17 percent performance capability to the Shuttle just with the Advanced Solid Rocket Motor. So for those reasons, at any rate, we proposed the program and so far it has been approved.

Mr. **Nagle**. You would concede, however, that that is not without risk to safety to go to the ASRM.

Admiral **Truly**. Certainly. It's not a concession, but there is no question that any new introduction into the vehicle of a change, no matter how small or large, has got to be addressed from that point of view, and we do.

Mr. **Nagle**. Now has there been a problem in the bidding process on the ASRM?

Admiral **Truly**. I'm not aware of a problem within the bidding process. We did have an issue that was reported publicly. Just after NASA got the proposals, there were some pages of one proposal that were noted to be missing. We took immediate action with the proper authorities to investigate that to see whether it was a theft or not. We drastically, or the Marshall Space Flight Center, which is responsible for the Source Evaluation Board, changed the security procedures around the Board and collapsed the number of people, and we also informed the Chairman of the Board of each of the lead companies in the two proposals of precisely what was going on, and I believe that has been contained to our satisfaction so that we leave a level playing field or a good selection going on. Now other than that, I'm not aware of any incidents with regard to the selection.

Mr. **Nagle**. Is the FBI still investigating that matter?

Admiral **Truly**. Both Arnie and I ever since the Board has convened, I have taken myself out of that process and it's being handled entirely by Marshall and the NASA IG. I believe the FBI was involved, and whether that investigation is complete or not, I don't know.

[The information follows:]

The NASA Office of Inspector General is currently investigating matters pertaining to the disappearance of documents relating to a proposal submitted on the Advanced Solid Rocket Motor procurement. Because this is an open criminal investigative matter, further information cannot be provided at this time. However, the Office of Inspector General will be glad to provide the Subcommittee with whatever information is releasable at the conclusion of the investigation.

Mr. NAGLE. Could you make inquiry for us, and since you have chosen to recluse yourself, I think that's the term, can somebody tell us the results of the FBI investigation or whether the FBI investigation is still going on, I mean from the agency?

Admiral TRULY. If I may, when I get back, let me speak to the NASA IG and let him respond to you.

Mr. NAGLE. You will request that he respond to me. It can be in writing, I understand.

Admiral TRULY. Yes, I definitely will talk to the NASA IG. I'm just not sure of the procedures nor of the status of what has been done since they started.

Mr. NAGLE. Okay. Now will you, when you receive the report of the ASAP with regards to its concerns on the safety factor of the ASRM, could you respond to us in writing, assuming they express some concerns about that or raise some questions about it, could you respond to us in writing as to NASA's response to those?

Admiral TRULY. Yes, we'll be glad to respond to the Committee.

[The information follows:]

The ASAP report in question was presented to NASA on March 28, 1989. The Office of Safety, Reliability, Maintainability and Quality Assurance is currently preparing NASA's formal written response to the ASAP report.

Mr. NAGLE. Thank you very much.

Mr. NELSON. Are there any other Members that have questions that are pertinent? I have questions from Ms. Morella and Mr. Volkmer that I need to ask for them, and we need to adjourn about 12:30.

Mr. MINETA. Mr. Chairman, what discussion has there been about Shuttle-C?

Mr. NELSON. We have had a fairly extensive discussion on Shuttle-C.

Mr. MINETA. Could I ask just one quick question on that?

Mr. NELSON. Sure.

Mr. MINETA. Admiral Truly, did you request monies of OMB for Shuttle-C since there is no money in the fiscal year 1990 budget for it? Did you ask for it, or did they on the pass-back cut it out?

Admiral TRULY. My memory fails me, but I think a year ago or over a year ago the agency made an agreement with OMB that we would continue our definition study of Shuttle-C, but that we would not put in a new start in fiscal year 1990, and therefore I did not put in an fiscal year 1990 new start for Shuttle-C, and therefore it was one thing that was not cut out of my budget. [Laughter.]

Mr. MINETA. It wasn't there. Well, the thing is that Dr. Fletcher was here and was very enthusiastic about it, and then yesterday again Mr. Odom was very supportive of Shuttle-C.

Admiral TRULY. The situation has changed quite a bit in the Advanced Launch System since the time the agreement was made. As a part of the lack of definition of where the Advanced Launch System was going at that time and Shuttle-C, and these were two potential heavylift systems, the agreement was made to not make it a fiscal year 1990 new start, but NASA would be encouraged and allowed to complete the definition studies, which we're doing, and we'll have a full-scale engineering development fixture of the Shuttle-C payload shroud at the Marshall Space Flight Center later this spring.

Mr. MINETA. Well, if you don't have it, then it seems to me you have a work force that is going to be, you know, there is a let-down and then you have to ramp up again in the following year.

Admiral TRULY. I am concerned about the fact that we do have contractor study teams in place in fiscal year 1989 that are being funded with fiscal year 1989 money, and in order to keep them in place, some fiscal year 1990 funding would be required if we choose to do that.

Mr. MINETA. What might you have asked for had that agreement not been there to keep the continuity going?

Admiral TRULY. We have an estimate of the Shuttle-C development. I don't recall the first year's funding. If in fact we just kept the contractors going at the same level they are now, it would be in the neighborhood of about $10 million.

Mr. MINETA. And I take it that agreement was with OMB then that you would not ask for funding, or who was that agreement with?

Admiral TRULY. That agreement was between NASA and OMB.

Mr. MINETA. Then if you will submit the runout for the Committee.

Admiral TRULY. I certainly will.

[The information follows:]

Shuttle-C is not contained in the President's FY 1990 budget per agreement between NASA and OMB. The following runout estimates include Design, Development, Test and Evaluation, and a Flight Test Unit and two Production Units.

PRELIMINARY FUNDING ESTIMATES

	1991	1992	1993	1994
Fiscal year:				
$M(TY)	80	400	700	1,100
$M($90)				

Source: National Space Launch Program, March 14, 1989, pg. 50

Mr. MINETA. Thank you very much.

Thank you, Mr. Chairman.

Mr. SKAGGS. Mr. Chairman, it's my understanding from yesterday's hearing that it's the Chair's intention to hold a separate hearing dealing essentially with all of the transportation capabilities associated with the Space Station and that we can get into the whole Shuttle-C and the alternative issue there. So with that expectation, I think we will see Admiral Truly again in that context I'm sure.

Mr. NELSON. He has a study going on right now about Shuttle-C, and when they get through with their study, we are going to get them up here. We're going to talk about it even though he is not anticipating that he's going to make a request until next year's budget. We may want to accelerate that, depending on his study. So we'll do that.

Mr. SKAGGS. Thank you.

Mr. Walker.

Mr. **Walker**. Thank you, Mr. Chairman.

I have also just a quick question on Shuttle-C. Is any thought being given to taking Shuttle-C commercial?

Admiral **Truly**. We are looking at that. We are trying to strategize what sort of an arrangement could be put together frankly to make the investment as small as it could be for a consortium of commercial operators.

One thing in the Shuttle-C program that you could do to do that, for example, is to lower the Shuttle flight rate, in other words, for NASA to provide the Shuttle infrastructure so that the Shuttle-C provided by a commercial entity would be the payload shroud itself. We are studying that possibility at the moment, but don't have a specific proposal.

Mr. **Walker**. Also, I was briefed recently and was told that there may be some possibility of extending the life of the Shuttle out to about the year 2020 instead of the year 2010. However, that might also involve a change of the flight regime because you would have to have about four months of down-time for refurbishing of Shuttles every so often in order to get that kind of extension of life in the Shuttle. Is that a real possibility?

Mr. **Aldrich**. I don't know about a specific study in that regard. In our current program we have down periods every three years planned on each Orbiter to do structural inspections in detail and not necessarily refurbishment. I think we'll need a few years of seeing how the structure fares in that environment before you could predict for another 10 years at the end of a long lifetime how much additional inspection or what refurbishment might be required. I don't think that answer will be apparent to us today.

Mr. **Walker**. Well, the problem, as I understand it, is if we don't begin the program though right up front that we lose the ability to keep them on line as we look further out. In other words, if we wait five years to begin the program, we may not be able to extend the life of them because part of the whole deal is to make certain that we are regularly bringing them back in for upgrade and refurbishment.

Mr. **Aldrich**. I believe we have started the program that would provide for that, and the first down period is on Columbia and it's in the early 1992 time frame.

Mr. **Walker**. Is that reflected in your flight manifest?

Mr. **Aldrich**. Yes. In fact, the same period is associated with the EDO mods.

Mr. **Walker**. You're convinced that in the early 90's before we have the fourth Orbiter on line that you can still run 12 flights a year with two Orbiters?

Admiral **Truly**. We will not have built up to 12 by the time we bring Columbia back. I think the flight rate that year, and I shouldn't guess, but it's less than 12. We don't get up to 12, 13 or 14 flights until the new Orbiter is delivered.

Mr. **Walker**. But if you are going to have down-time on these Orbiters, it seems to me at no time you're going to be flying more than three Orbiters. I mean if you need three or four months of down-time, and let's go to the mid-90's, let's go to 1993/1994, if you need three or four months of down-time in order to keep them on this program, you're going to have a consistent situation where you're going to have three Orbiters available to you rather than four Orbiters available to you. I don't see how you can possibly ever get to 12, 13 or 14 flights a year running only three Orbiters.

Admiral TRULY. I believe, and I can provide this to you and show it to you, but I believe that the down-times are shorter than you might think. In our manifest, which does show how we build up the flight rate, we do have structural inspection periods that are built into the manifest, but in any given year we still operate all four Orbiters.

[The information follows:]

The recently published Space Shuttle manifest (January 1989) shows flight rates approaching 14 flights per year following the first flight introduction of the new orbiter in 1992. The flight schedule was laid out using the following assumptions and ground rules:

a. *Processing facilities*—(1) Three Orbiter Processing Facilities (OPF) in operation; (2) three Mobile Launch Platforms (MLP); and (3) two launch pads.

b. *Orbiter processing flow (per flight)*.—(1) 51 workdays for Orbiter preparation; (2) 6 workdays in the Vehicle Assembly Building (VAB); and (3) 21 workdays on the launch pad.

c. *Airframe Structural Inspection*.—(1) Major inspection every 3 years for each orbiter; and (2) 20 days serial downtime per inspection, incuding anticipated repairs and refurbishments.

d. *Mission Duration*—(1) Nominal missions—7 days; and (2) extended duration—two to three 16-day flights per year.

e. *Landing Site*.—(1) 40 percent at KSC, 60 percent at EAFB.

As noted, planning includes provision for performing repairs and/or refurbishments within the nominal inspection period. Major repairs or improvements requiring additional downtime would result in reducing the flight rate.

Mr. WALKER. But my understanding of the program that we were being told about, if I understood correctly, was that it would require longer periods of down-time and this is more than inspection. This would be taking the Orbiter and upgrading them regularly, and it would probably take three or four months of down-time in order to do those upgrades, but as a result the life expectancy of your Orbiter fleet goes up substantially, and so therefore we get a real payoff from it.

I'm gathering that that is not something which is really being discussed internally within NASA and that this may be people looking at the system from the outside?

Admiral TRULY. Let me tell you want we are doing. I'm not familiar with a specific plan to extend the Orbiter based on long down-times as you described. But what we are doing is we are trying through our structural spares program to keep the contractor force and the capability to build a new Orbiter, which we undoubtedly would want to do if we are going to extend the life of it and, secondly, to have a good operational program so that we routinely do bring the vehicles down for a short period of time, inspect them and make minor structural mods.

Mr. WALKER. Well, I guess from my perspective, I'm a little concerned that there is not enough money in the budget for structural spares this year. I mean I agree with that program, but I'm concerned that we don't have nearly enough money in the budget for this year to deal with the structural spares problem and to have the kind of ongoing structural spares situation that will allow us to do that properly. That has been something that this Subcommittee has addressed on regular occasions, and I assume we are probably going to come back and address it again because that is a place where we have literally had to force you to take the money in some years past.

Admiral TRULY. I must say that I share your concern about the level of effort that is in the structural spares program. It is at a minimum and will not make the progress in 1990 that could be made. Nevertheless, it is not as important to us as engine testing and some of the things that have to be done. Therefore, we had to reduce it to a minimum level that we do think is manageable, but it will not make the progress that we had initially planned.

Mr. WALKER. Thank you.

Mr. NELSON. I was just getting ready, Mr. Volkmer, to ask a question on your behalf about structural spares. So I'm going to turn it over to you, and I'll turn the Chair over to you.

Before I depart, let me introduce Admiral Truly. She is with us here, and we are delighted to have you. It is always a pleasure, very much so.

Admiral TRULY. Thank you.

Mr. NELSON. And on behalf of Mrs. Morella, she had wanted me to ask you, Dr. Fisk, could you tell us the status of the Lightsat program.

Dr. FISK. Let me give you two answers to the question, and I will be brief about them.

In the Strategic Plan, it is the small mission option to begin after Earth Probes. Earth Probes is not included in the 1990 budget. So Earth Probes will be a 1991 initiative, and Lightsat at the earliest could be a 1992. We are entering into a Phase B study at this time, and there is an RFP out to chose Phase B contractors.

Mr. NELSON. Mr. Volkmer, if you would take the Chair.

Mr. VOLKMER [presiding]. I'm sorry I couldn't have been here earlier, but I had another committee which I Chair that I had hearings on. So I can't be two places at the same time.

Admiral Truly, the structural spares thing is really a matter that concerns me as one who has been through it before, and I'm happy we did because of what occurred and then looking down in the future.

I guess I could start off with some preliminary things and see if you agree or disagree with my thought processes as we go along, and it gets me to a certain conclusion. That is what we are going to be using the Shuttle for, as a means to transfer bulk commodities from here on earth, basically that, that's what our goal is to at least the year 2010, in that time frame, will we not?

Admiral TRULY. I think so, 2005 to 2010, and there might be a possibility to extend the Orbiter even farther if we provided the right plan and resources to do that.

Mr. VOLKMER. Now we have seen, and I know that we all learn from mistakes, not necessarily mistakes, but we learn from experience also, and we have seen what happened to the Challenger. We know that by 1992, if everything goes well, we'll have the three that we presently have, plus we will have a fourth, but right now it appears to me that there is no vision to have any additional.

Admiral TRULY. I'm concerned about that, too, and that is the very reason that the structural spares program in my mind is so important. It allows us to keep the ability to build a new vehicle when we decide to do that.

Mr. **Volkmer**. But if it's going to cost that much more if we continue to let all these lines shut down, that's the thing that I've been through before, and the way I understand what's happening, and the tooling for the wings, let's take those at Grumman. What is the position of Grumman right now as regards to what to do with that tooling?

Admiral **Truly**. Can you address that, Arnie?

Mr. **Aldrich**. I haven't got an extremely current report on that, but I know that we are not building wings today because the previous structural spare wings have been delivered long ago and are part of 105. So the tooling is in place and taking a large amount of facility at Grummond and is not in use, and that is not an effective or a pleasant arrangement for any contractor to have their facilities cut up.

Mr. **Volkmer**. Are they going to continue to do that for another 2, 3, 4 or 5 years?

Mr. **Aldrich**. I'm sure they will not want to do that and they will be eager to make some other arrangement to either remove or put the tooling in some other configuration or be surplused of it.

Mr. **Volkmer**. And we've got tooling, or we did have some in San Diego, but I guess some of that has been already moved; is that correct?

Mr. **Aldrich**. Yes. I believe General Dynamics has removed the tooling that was used for the mid-body, and if we were to go to structural spares in this program that fully does a mid-body, that will probably be done by another contractor.

Mr. **Volkmer**. Well, can you or anybody that you know assure us that somewhere in the 90's time frame that we won't have say a problem with a wheel or something that may cause a problem with a wing on one of our Shuttles?

Admiral **Truly**. No, I don't think that anyone could assure you of that because no matter what we do, we cannot totally take risk out of the system, and the possibility of damaging an Orbiter always exists when you're flying.

Mr. **Volkmer**. That's what I say, we always have that problem, and not necessarily losing one, but even damaging one and then you can't replace it until you go back and rebuild that thing.

That gets me to the point where I'm still stressing, and it has been something of a big interest to me to get this structural spares program on the road again since we are using those spares now to replace the Challenger. What I find is that the budget of course, or OMB has pulled has pulled us back to where we really can't do anything with $15 million, can we?

Admiral **Truly**. I should ask Arnie to comment on that, but we believe with $15 million we can protect the capability.

Mr. **Volkmer**. But you're spending money without a product.

Admiral **Truly**. But we certainly cannot make the progress that we had hoped to make——

Mr. **Volkmer**. With the $65 million.

Admiral **Truly** [continuing]. With about $65 million, which is about what would be an appropriate level if we were moving out to build a set of structural spares in the situation we are in today.

Would you like to comment on the $15 million.

Mr. ALDRICH. Well, our first objective will be to maintain production capability in areas, and there are some areas that aren't classed as structural spares that need to be looked at and are being looked at. There are other components that are part of the Shuttle system that the vendors have finished their work, and when their program of support to the spares and logistics supply is adequate, they literally would terminate manufacturing Shuttle parts, which could be critical in a downstream time frame. So we must look at that.

I think the $15 million will be adequate to allow us to keep the ability to build Orbiters going through that year, but it's like a nine-month delay in a real robust build-up if in fact we fund in 1991 and upbeat program.

Mr. VOLKMER. Now according to the information that I have seen in some communications, it does appear that we are going to have an underrun on OV-105.

Admiral TRULY. The 105 contract is going very well. Today, and it's far too early to see where that contract is going to end up, but today the build of the Orbiter is going well, they are on schedule, they have been under cost and as a matter of fact, and it may not be totally obviously in this budget submission, but Arnie in trying to deal with the total fiscal situation that he has found himself, we have agreed where appropriate to do some of the work that would have normally been in the normal Shuttle budget within the 105 program.

A good example is an engine improvement called a heat exchanger. It's called the external heat exchanger. It's totally appropriate we believe to develop that using 105 money in that part so that we didn't have to further degrade the situation within the normal Shuttle budget. So we made sure that that was okay with the committees and we actually are spending that money in the 105 budget. So the budget is going well, but it's a little early to project how it's going to come out.

Mr. VOLKMER. All right. I have seen a letter I believe from Mr. Fletcher that says:

> We would proceed to implement provisions for EDO on the ELV-105 by applying $27 million of the fiscal year 1987 funding provided for the replacement Orbiter.

Now that is $27 million underrun if you are going to take it, at least that is the way I read it. Do you disagree with that? I'm in favor of the EDO, no question about that, but that's another question. Right now I'm looking at the underrun.

Admiral TRULY. The portion of the EDO that would go to "SCAR" or equip the OV-105 as it is being built for extended duration, we did make the agreement that because of the situation that we are in, and we have the money in the line item now, we agreed that we would pay for the 105 portion of the EDO out of the 105 money.

Mr. VOLKMER. Well, that means that you had additional money in the 105 that you would use for EDO, which means to me, I would call that an underrun. If you didn't have the EDO to use it for, you wouldn't need it for the completion of 105.

Admiral **Truly**. I'm certainly not trying to play word games about underrun or flexibility.

Mr. **Volkmer**. I use that as an expression.

Admiral **Truly**. Yes, we do see the flexibility within that line item to pay for that portion of the EDO that affects the 105 vehicle.

Mr. **Volkmer**. All right. Now the rest of the EDO funding, where is that going to come from if we are looking at it also for the existing?

Admiral **Truly**. There are monies in the fiscal year 1990 budget, and we have monies in fiscal year 1989 that we are moving out to develop the basic capability. However, let me be quick to point out that the assumption has been made in the EDO budget that the availability of private financing will be available because the runouts that are in the budget are inadequate to deliver an EDO on the schedule that we are on without the gaining of additional funds either through private financing or an appropriation.

Mr. **Volkmer**. Well, before I get to that, we have found the $27 million and we are doing some things different that we have learned in constructing the 105. How much more flexibility do we have? In other words, I don't want you coming back here next year and telling me, Mr. Aldrich, I don't want you coming back here next year and telling me that we're able to use another 25 or 50 or 35 or anything else that you didn't need to make 105 and now you can use it for something else.

Mr. **Aldrich**. Mr. Volkmer, when we started the 105 we knew it was a new vehicle and a new time frame, and when we contracted for it we left some flexibility in the NASA line item beyond the contract to cover contingencies. As we progressed over the last year and a half we not only have not needed the contingency money that we might have had given different circumstances, but because of the way the cost sharing is between the contractor and NASA, we have had a beneficial underrun that has been beneficial to both parties.

So we have had the availability of this flexibility that we didn't need to use, but which we might have, and as we get further along it's more and more apparent that it will be surplus and, in addition, we are doing very well on the cost line and therefore we'll probably have an aggregate underrun at the end of the build.

Mr. **Volkmer**. An aggregate in excess of $100 million?

Mr. **Aldrich**. That's possible. We are not that close to the end that we can assure it yet, but the trend is in that direction.

Mr. **Volkmer**. Well, as one who wants both the spares and EDO, I would like to work with you and not have to work against you and not have to do something that embarrasses anybody or makes it look like somebody is not for spares, because I know you want spares also.

Admiral **Truly**. I certainly do.

Mr. **Volkmer**. I would like to work with you to see if we can work this out where we can find the funds to do both of them because I think both are very important to the future. I would wish that we would never need another spare. That would be nice. But I don't know, I don't think anybody can say.

Admiral TRULY. Well, I certainly do wish that we would, too, but when you have the responsibility to manage the program and you are accountable for it, you have to be practical people.

I think one of the great pluses at the time of the Challenger accident was the fact that the Congress had been wise enough to approve our previous request for structural spares or this 105 that we are building today in 1991 wouldn't be showing up until 1993 or so.

I have been a strong proponent of structural spares and wish that we had not had to reduce the budget as we did in FY-90.

Mr. VOLKMER. Another little point has been brought out to me, and I think it's worth pursuing. The 105 contract was different than the contract on any other previous Shuttles, correct?

Mr. ALDRICH. Yes, sir, it was.

Mr. VOLKMER. And basically it's because of the full funding. In other words, the full funding that you had, how much did that contribute to efficiencies and savings in the making of 105?

Mr. ALDRICH. I'm not sure that I could comment on having full funding up front if we were confident that the full funding would be provided. I believe the bigger effect on the efficiencies has been the cost sharing with the contractor to underrun and him sharing in a portion of the underrun.

Mr. VOLKMER. It was the way the contract was made as far as incentives.

Mr. ALDRICH. Yes and, in addition, we also specified that we would build it to the prints of the Atlantis 104, the last vehicle to be built. So it is not a change vehicle. It is a repeat and built with this incentive to build it economically.

Admiral TRULY. I would like to comment very briefly. I don't think I could quantify the advantage of having the full funding, but in a qualitative sense I would say that it gave us the flexibility to strike a hard but fair agreement with the contractor on a cost line that gives them the incentive to build us a vehicle we want on the schedule we want and under cost. So I think it was of great value, but putting that in dollars and cents, I don't think I could do that.

I have seen many other programs that have been seesawed, and therefore the final result was not exactly what we had originally wanted and at higher cost and later.

Mr. VOLKMER. I want to thank all three or four of you I guess for your testimony. I'm sorry, like I said, I couldn't be here for the full amount. As I said, I'll be glad to work with you in the next few weeks or so and see if we can't work something out on this.

With that, the hearing will conclude.

[Whereupon, at 12:50 p.m., the subcommittee adjourned, subject to the call of the Chair.]

1990 NASA AUTHORIZATION

TUESDAY, MARCH 7, 1989

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met at 2:14 p.m. in room 2226, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Present: Representatives Nelson, Mineta, Stallings, Perkins, Smith of Texas, Buechner, Rohrabacher, and Morella.

Mr. Nelson. Good afternoon.

We are going to continue the authorization hearings for the 1990 budget. Today we are going to review two very important activities of the space agency.

We are going to hear from Mr. Aller, who is NASA's Associate Administrator for the Office of Space Operations. Then we will turn to Dr. Rosen, the Associate Administrator for the Office of Aeronautics and Space Technology.

The Office of Space Operations and its tracking and data networks play a very key role in the agency. Without these networks, NASA couldn't communicate with the shuttle, and sophisticated satellites such as the Hubble Space Telescope would not be possible.

In fact, later this year, August 24, we will see for the first time close-up pictures of Neptune which is made possible, in part, by improvements to the deep-space communications network. This event will be taking place 20 years since man first stepped on the moon, showing the degree to which we have advanced and that we are penetrating the solar system.

This upcoming shuttle launch, one early next week, and the deployment of its TDRS payload is a big one for Mr. Aller's office, and we hope to learn more of its status and the corresponding closing of some ground stations in the network.

Then, in the area of Dr. Rosen's space research and technology, we just simply continue to be concerned about the lack of adequate funding for this key element of our space industry.

We are also concerned by the tendency of high rates of turnover in the upper management ranks of the Office of Aeronautics and Space Technology.

We are a little bit late because I have just come from giving a speech, and I have given it on setting a vision for this Nation, what that vision ought to be. We are never going to be able to have the

98-466 O—89——16

President set a vision and get there if we do not give the adequate resources to research.

So, I want to thank you for participating today. You all have certainly been full well warned that we do not have witnesses reading speeches in here. So, just talk to us.

Mr. Aller, if you would proceed.

Both statements will be made a part of the official record, the printed record.

STATEMENT OF ROBERT O. ALLER, ASSOCIATE ADMINISTRATOR FOR SPACE OPERATIONS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. ALLER. With your approval, I will submit my statement for the record.

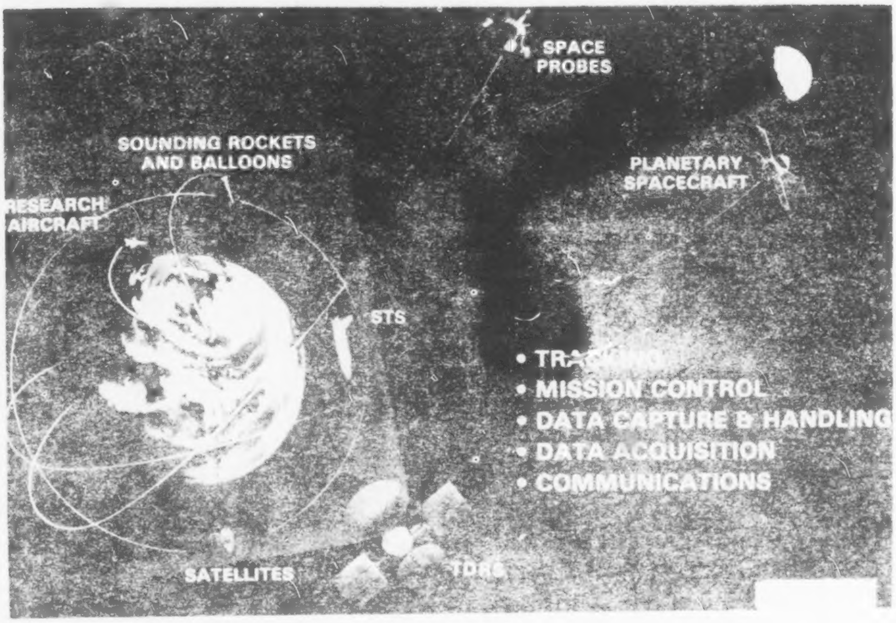
Mr. NELSON. It is already approved.

Mr. ALLER. It is a pleasure to be here again. I believe this is our fifth time at this, Chairman Nelson. I think this year it is a pleasure for me because in the past year we have made a lot of progress. We have brought to a degree of fruition some of the things we have been talking about the previous 3 or 4 years, and we have a very exciting future in 1990, the budget that is represented for 1990.

I will proceed in a discussionary manner. I have brought some viewgraphs to make some points. I will try to move through them rather rapidly. However, let's discuss the points as we go, if that is what you prefer, sir.

May I have the first slide, please (fig. 1).

TRACKING AND DATA ACQUISITION FUNCTIONS


SPACE PROBES
SOUNDING ROCKETS AND BALLOONS
PLANETARY SPACECRAFT
RESEARCH AIRCRAFT
STS
SATELLITES
TDRS

- TRACKING
- MISSION CONTROL
- DATA CAPTURE & HANDLING
- DATA ACQUISITION
- COMMUNICATIONS

I would like to point out that in 1988 and to the present we have made a lot of progress. Specifically, as you mentioned, we have sucessfully launched the second TDRS, have it in orbit. It was checked out early and made operational. It is a real tribute to the improvements we have made on the ground systems in support of the TDRS program.

We have completed the 70-meter net, the large network of antennas around the world that we have been working on for several years.

We have completed our unique support effort for Voyager and I will talk about that briefly.

We delivered in 1988 the fourth TDRS spacecraft, the third one to be launched next week. And we awarded the contract for the second ground terminal to the GE Company.

Next slide, please (fig. 2).

NASA

MAJOR FY 1990 PROGRAM OBJECTIVES

- PROVIDE TRACKING, COMMUNICATIONS AND DATA SYSTEMS SUPPORT TO ONGOING AND NEW MISSIONS
- MAINTAIN STGT IMPLEMENTATION SCHEDULE
- PROVIDE FOR TDRS-5 AND -6 AVAILABILITY
- MAINTAIN TDRS-7 DELIVERY SCHEDULE
- UPGRADE SUPPORT SYSTEMS TO MEET NEW REQUIREMENTS FOR GALILEO; MARS OBSERVER; TOPEX; CRAF/CASSINI; HST; GRO; COBE; AXAF; AND THE GROUP OF SOLAR TERRESTRIAL PHYSICS MISSIONS (GEOTAIL, WIND, POLAR, SOHO, AND CLUSTER)
- CONTINUE PLANNING FOR MAINTAINING THE FLOW OF TDRS SPACECRAFT AVAILABILITY AFTER TDRS-7
- MAINTAIN DEVELOPMENT OF SPACE STATION AND PLATFORM SUPPORT ELEMENTS, INCLUDING THE CUSTOMER DATA AND OPERATIONS SYSTEM (CDOS).

Figure 2

Figure 2 depicts our objectives for 1990. Our prime objective always is continued tracking, communications, and support of the ongoing missions and for the new missions. The new missions ahead of us, of course, are COBE, HST, as you mentioned, ROE in the next year. Plus the planetary missions, Magellan and Galileo. And we have done a lot of work and a lot of preparation for all those missions.

We hope to maintain in the 1990 budget the second ground terminal and the implementation schedule that I will talk in more detail about.

We of course need to continue to provide the availability of the TDRS spacecraft, the fifth spacecraft and the sixth. And to maintain the delivery schedule of the replacement spacecraft that we have been building since the Challenger accident.

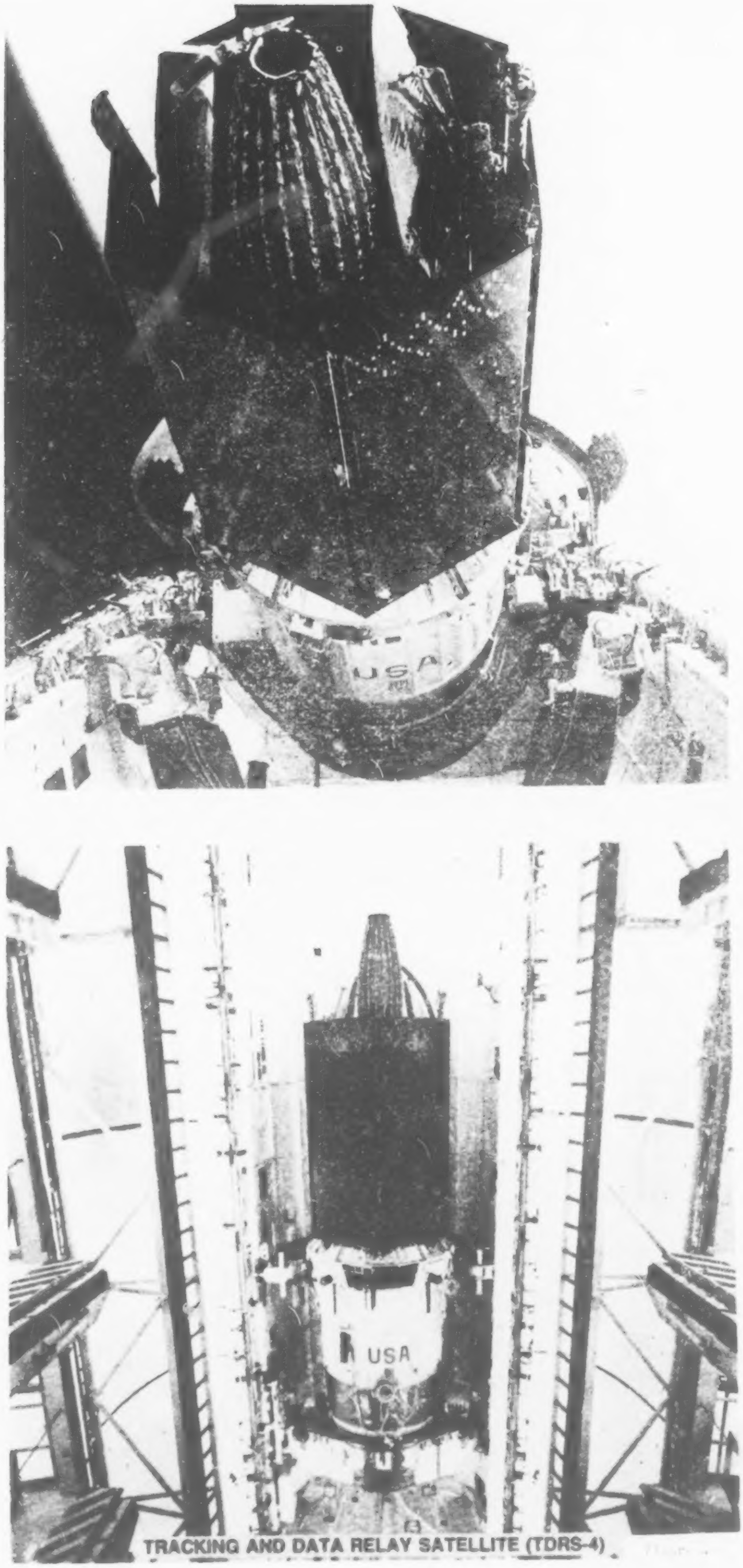
We have a considerable number of upgrades that are listed on the chart that have to do with all the upcoming missions.

Much of our program, although I will show you in the budget, about $700 million of our program goes into operations, some $400 million goes into upgrading the systems and uniquely for each of the programs.

We need to continue to maintain the TDRS-7 spacecraft for its availability in late 1992, early 1993. And we need to initiate efforts in the development of our space station support.

Those are our major objectives as we go into the 1990 time frame with this budget.

The next two slides—James, real quickly please (figs. 3, 4).



TRACKING AND DATA RELAY SATELLITE (TDRS-4)

Just to show you, you mentioned the status of the spacecraft we are about to launch. The one (fig. 3) on your left is of course the one we launched in September. The one (fig. 4) on the right is pictured down at the Cape. It's at the pad. It's in a battery charge at the present time. The doors will be closed at T minus four days, roughly. And we are anticipating the day of launch of that vehicle on the 13th.

Next slide, please (fig. 5).

TRACKING AND DATA RELAY SATELLITE SYSTEM (TDRSS)

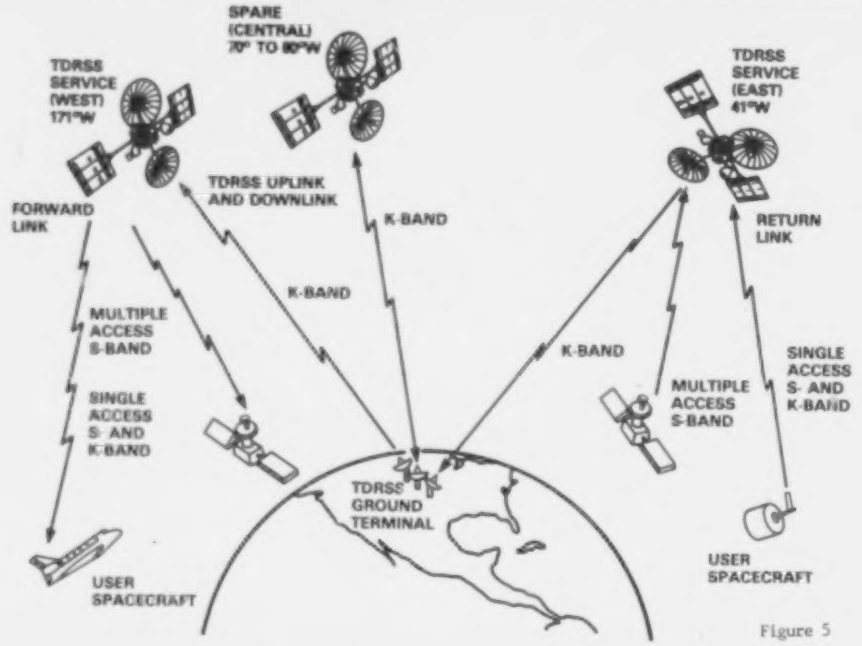

SPARE
(CENTRAL)
70° TO 80°W
TDRSS
SERVICE
(WEST)
171°W
TDRSS
SERVICE
(EAST)
41°W
TDRSS UPLINK
AND DOWNLINK
FORWARD
LINK
K-BAND
RETURN
LINK
K-BAND
MULTIPLE
ACCESS
S-BAND
K-BAND
SINGLE
ACCESS
S- AND
K-BAND
SINGLE
ACCESS
S- AND
K-BAND
MULTIPLE
ACCESS
S-BAND
TDRSS
GROUND
TERMINAL
USER
SPACECRAFT
USER
SPACECRAFT

Figure 5

The TDRS program itself, with the coverage that we have been planning for several years, we now have the green satellite, which was launched in 1983 on orbit. It of course has decayed considerably in that we have had major failures aboard that spacecraft. However, it is functional today.

The yellow spacecraft shown in the diagram is the one we just launched. It is on location over the western Pacific. It is fully operational.

When we launch the fourth spacecraft next week we will eventually move it into the green location and drift the satellite that is there today into the spare location. So, we will have a full configuration, hopefully, with the successful launch of TDRS-4. And that is key to some of our other plans as they affect the closure of ground stations.

Next slide, please (fig. 6).

STS NOMINAL GROUND TRACK (160 N. MI. ORBIT)

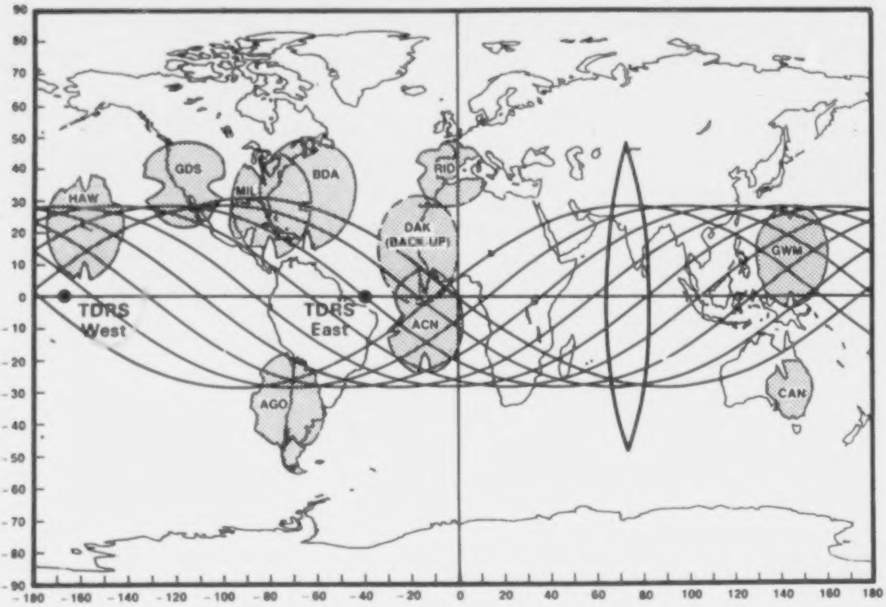

HAW
GDS
BDA
MIL
RID
DAK (BACK UP)
ACN
GWM
AGO
CAN
TDRS West
TDRS East
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-180
-160
-140
-120
-100
-80
-60
-40
-20
0
20
40
60
80
100
120
140
160
180

Figure 6

One of the things, of course, this is done, the chart on your right—put the overlay; no, leave that, please. Put the overlay down.

I just am pleased to demonstrate with this chart the kind of coverage that we now have with TDRS—since the time you flew your mission, as a matter of fact. We will be able to watch you all the time now, except for the small wedge over the Indian Ocean.

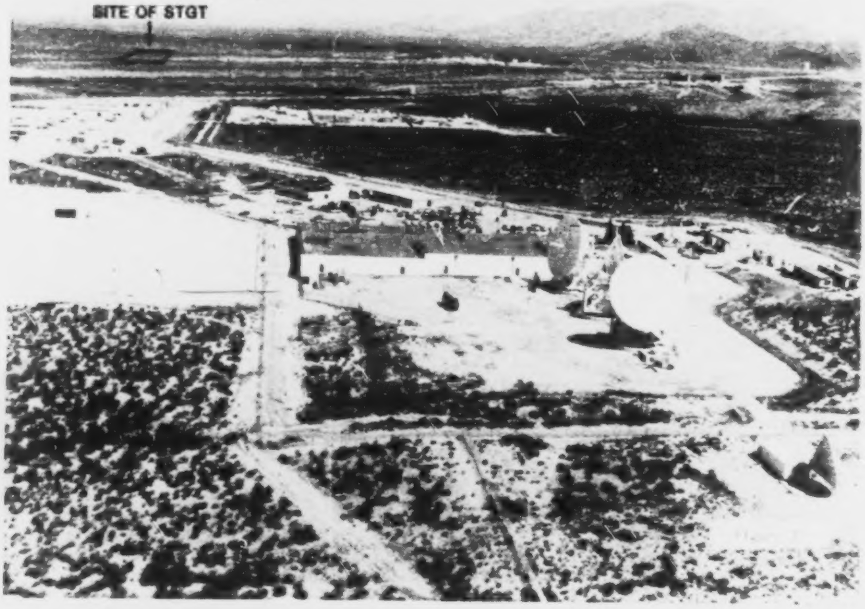
It effectively is changing the way we operate the shuttle. It is such that the communications with the crew are greatly reduced, and that questions back and forth as to what has happened out of coverage are no longer necessary. We can monitor more or less in realtime all the activities that are taking place in the way of experiment data and/or shuttle data.

So, from the coverage that was shown without the overlay with the stations—and you can still see it on the chart—we have immensely increased the coverage and the capacity we have both for safety and for data gathering on all of our missions.

I would like to shift now in my discussion to the second ground terminal. I think it is key in the budget this year.

The site for the second ground terminal is shown on your left (fig. 7). The building that we have just completed is shown on the right (fig. 8). And we are proceeding, as I indicated earlier, with GE as the prime contractor. And we initiated that contract in December of this year—in 1988.

TDRSS GROUND STATION
WHITE SANDS, NEW MEXICO


SITE OF STGT

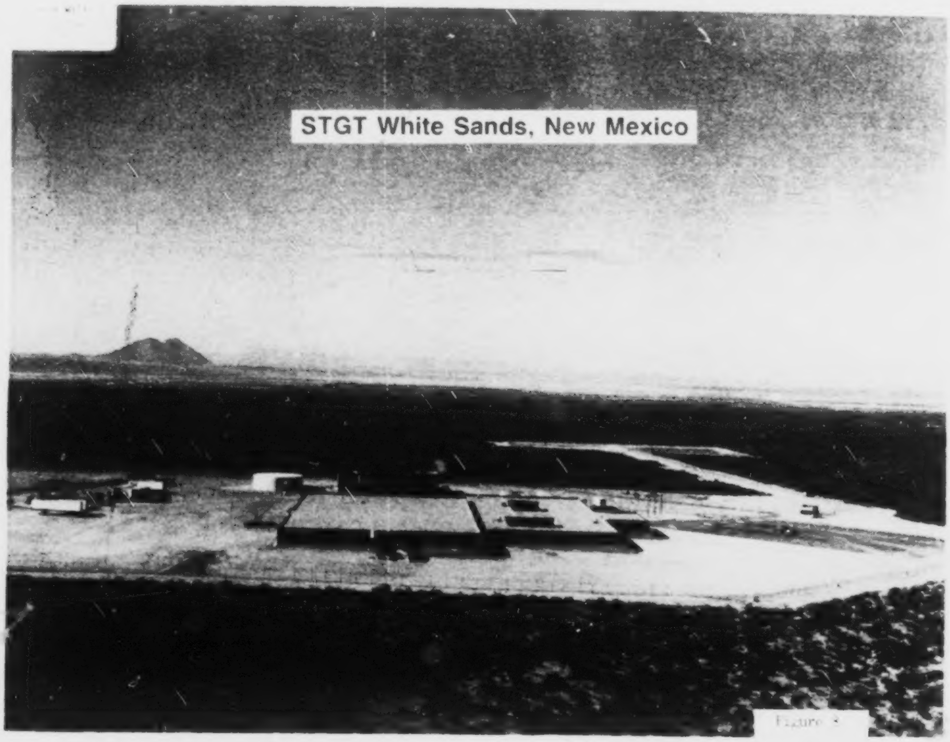
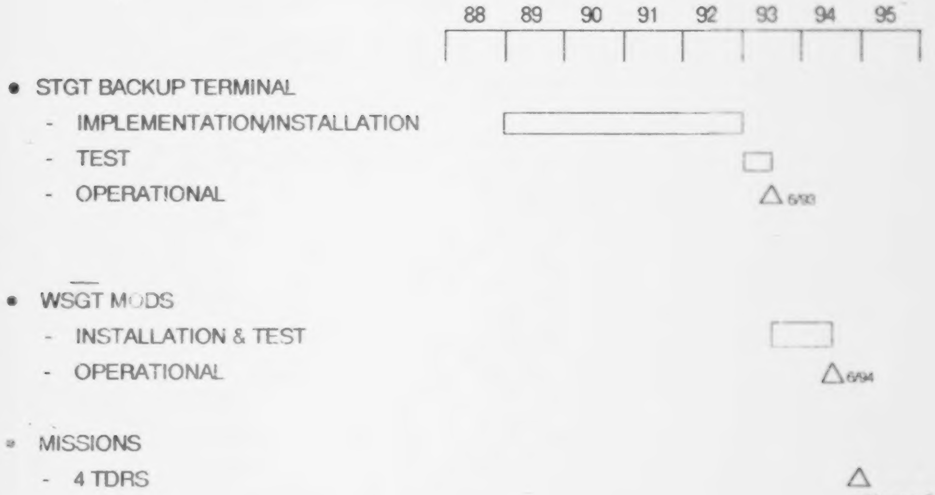

STGT White Sands, New Mexico

Figure 8

The station, as indicated, is up the valley from the present site, and we plan to implement a configuration in antenna similar to the one shown here. And of course, it's entirely new design with the ground station itself.

Next slide, please (fig. 9).

SPACE NETWORK
SECOND TDRSS GROUND TERMINAL AND
WHITE SANDS GROUND TERMINAL
BASELINE PLAN



- STGT BACKUP TERMINAL
  - IMPLEMENTATION/INSTALLATION
  - TEST
  - OPERATIONAL
- WSGT MODS
  - INSTALLATION & TEST
  - OPERATIONAL
- MISSIONS
  - 4 TDRS

Figure 9

Very important to that program, Chairman Nelson, is the schedule that we are on to complete the second ground terminal and to upgrade the existing ground terminal.

I have shown on this schedule that we hope to become operational with the backup terminal in mid-1993. That is taking into account the delay we had with the budget in 1989 and the delay we have already taken from the OMB mark in 1990.

With that, we will immediately upgrade the White Sands ground terminal and we will have those equipments checked out in the secondary ground terminal and transfer them into the present ground terminal over a year's period of time such that we can in late '94 go in to a four-spacecraft configuration in orbit with both ground stations fully operational.

That is the schedule we are on, and the budget that we have in 1990 supports that schedule.

I should reemphasize again that the three reasons that we need the second ground terminal are: first and foremost, we need a backup for the present ground terminal, the single failure point on the system; we need a capability to upgrade the present ground terminal from the older technologies; and we need added capacity to operate four spacecraft in orbit. Those are the three aspects of the rationale.

The next slide, James (fig. 10).

SECOND TDRSS GROUND TERMINAL
WHITE SANDS GROUND TERMINAL
MANPOWER PROFILES
FOR FY 90 BUDGET PLAN

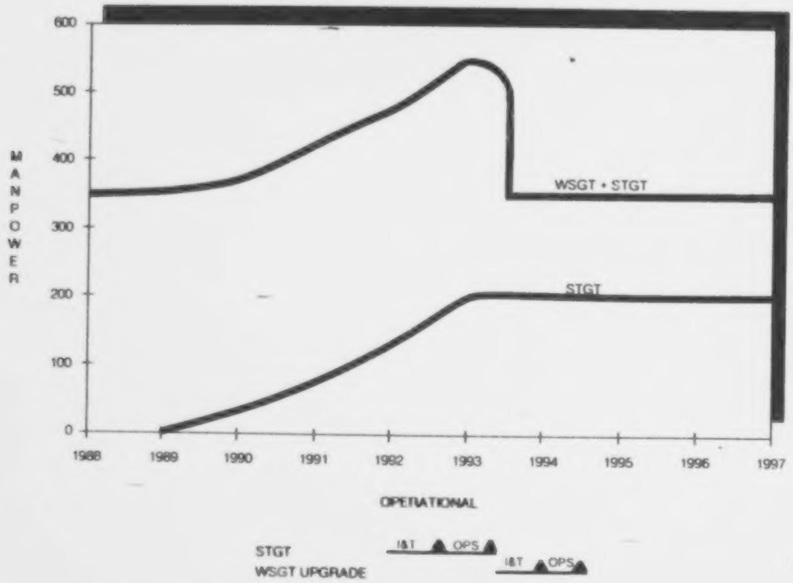


Figure 10

This is the one that I wanted to show you on the manpower at White Sands. This chart depicts that we presently have a little over 350 people at White Sands to operate the present ground station. With the second ground terminal configuration—and a repeat of that configuration of present ground terminals—we will build up over the interim period, on the red line, and be able to reduce when we tear down the present terminal and be able to operate both the present White Sands ground terminal and the second ground terminal with the same number of people as we have at White Sands today.

That is due to the configuration that we have established and the software programs associated with that configuration.

Next chart (fig. 11).

TDRSS Configuration for Space Station Initial Operation

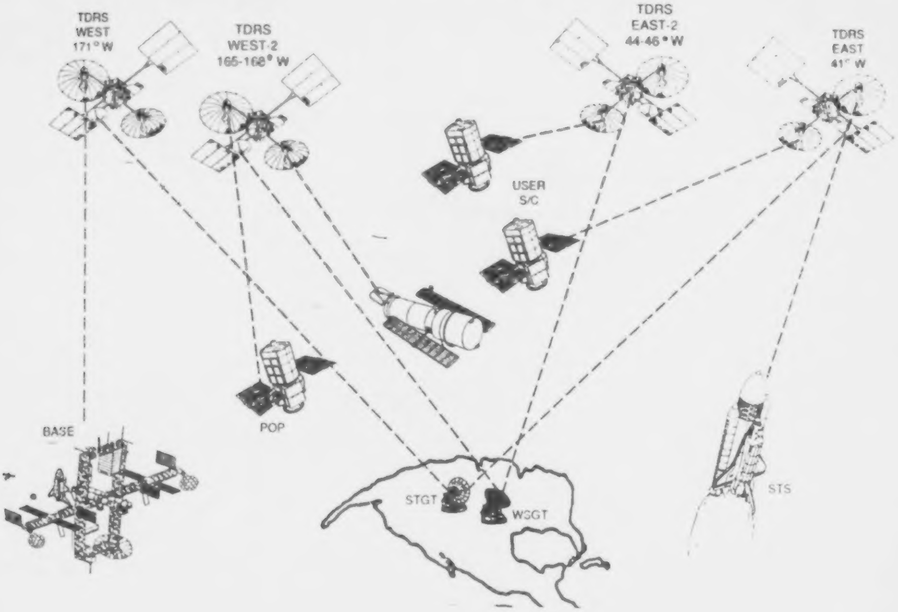
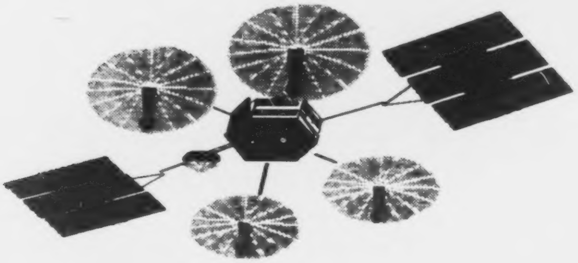

TDRS
WEST
171° W
TDRS
WEST-2
165-168° W
TDRS
EAST-2
44-46° W
TDRS
EAST
41° W
USER
S/C
BASE
POP
STGT
WSGT
STS

Figure 11

This depicts the configuration that it will support, which effectively is we will move the spare into the east location and the fourth spacecraft goes into the west location. So, effectively we have four spacecraft to operate with fully in support of the user community.

ADVANCED TDRSS



- FOUR SA ANTENNAS INCREASE CAPACITY AND REDUCE LIFE CYCLE COSTS
- INCREASED DATA RATE SA SERVICES
- S-BAND MA (HIGHER DATA RATE)
- NEW SA RF BAND (Ka OR W) IN ADDITION TO S AND Ku BANDS

Figure 12

The chart (fig. 12) on the right then, moving on into some early studies we have in the 1990 budget and then it builds up in the out years, is the advanced TDRS, the program that will replace the spacecraft in orbit. And this is a simple configuration sketch. But it indicates the kind of capability that we are talking about to come on line in about the 1997 timeframe.

The basic capacities that we are increasing are what we call the multiple-access or the lower data rate capability and the wider bandwidth that will be available most likely through KA band operation.

We planned it to configure the spacecraft with additional antennas so that we effectively would have four operational antennas instead of two as we have on the present spacecraft.

With that I would like to move on to the ground stations.

Could I have the next slide, please (fig. 13).

NASA SPACE OPERATIONS TRACKING NETWORKS (1988) (1990)

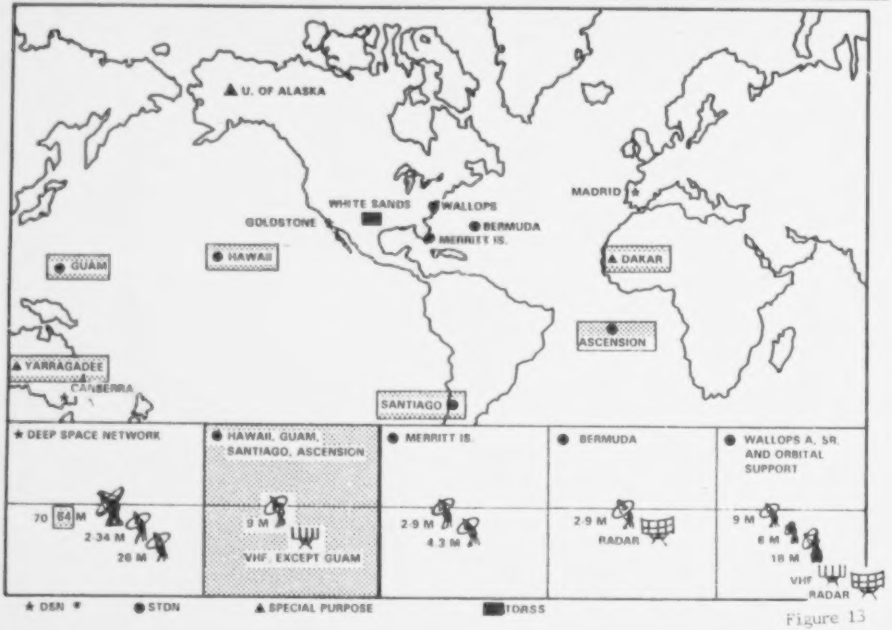

U. OF ALASKA
WHITE SANDS
WALLOPS
GOLDSTONE
BERMUDA
MERRITT IS.
MADRID
GUAM
HAWAII
DAKAR
ASCENSION
YARRAGADEE
CANBERRA
SANTIAGO
DEEP SPACE NETWORK
70 64 M
2·34 M
26 M
HAWAII, GUAM, SANTIAGO, ASCENSION
9 M
VHF, EXCEPT GUAM
MERRITT IS.
2·9 M
4·3 M
BERMUDA
2·9 M
RADAR
WALLOPS A, SR AND ORBITAL SUPPORT
9 M
6 M
18 M
VHF
RADAR
DSN
STDN
SPECIAL PURPOSE
TDRSS

Figure 13

This is the chart that depicts the ground station locations worldwide. And as I have used in previous years, the hatched marks at the station indicate those stations that we plan to close at the end of this year as a result of the completion of the operational phase of TDRS.

I must emphasize that that closure is fully dependent on our ability to launch this next spacecraft and fully check it out.

We will be closing Guam, Hawaii, Santiago, and Ascension, and in 1991 timeframe we will be closing the Dakar station in eastern Africa.

Those plans are proceeding. We plan to turn the stations over to other sponsors at Hawaii, Ascension, and Santiago. At the present time, the station at Guam would be closed. There are ongoing discussions with other Government agencies regarding Guam, but at this point in time we plan to close that station.

[The prepared statement of Mr. Aller follows:]

HOLD FOR RELEASE
UNTIL PRESENTED
BY WITNESS

STATEMENT OF

ROBERT O. ALLER

ASSOCIATE ADMINISTRATOR

FOR SPACE OPERATIONS

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications

Committee on Science, Space and Technology

House of Representatives

Mr. Chairman and Members of the Subcommittee, thank you for providing this opportunity to present our FY 1990 budget request for Space Operations.

INTRODUCTION

A vital element of the infrastructure needed to conduct research and science in aeronautics and space is the capacity to communicate with and receive, distribute and process information from space vehicles and aircraft.

The Office of Space Operations is responsible for the planning, development, and operation of worldwide tracking, data acquisition, data processing and communications systems, facilities, and services which are required to support unmanned and manned orbital spacecraft, deep space platforms, radio science, sounding rockets, balloons, and research aircraft.

The major resources used to accomplish these functions include:

- Networks of ground stations to track and command/control Earth orbiting and deep space missions: "The Ground Networks."
- A series of geostationary satellites currently being deployed and associated ground support equipment which will support most Earth-orbiting missions: "The Space Network."
- Facilities and services for communications from the Ground and Space Networks to control centers and data handling facilities; and for Agency administrative communications.
- Data handling facilities to capture, merge and collate data collected by these networks in preparation for further processing and analysis.
- Facilities for spacecraft and mission operations control and for flight dynamics determination and control.
- Skilled managers, engineers, and operators to design, maintain, and operate these systems and unique operational facilities for the conduct of space flight missions.

These resources provide the connections that are necessary for our flight programs to achieve their operational goals; and are used additionally to support other agencies and our international partners. A significant element of this support is the ability of the NASA installations to provide skilled program personnel critical to this operation. Adequate institutional funding is vital to meet our operational requirements.

A portion of our on-going operational communications support was reactivated to meet the needs of our return to shuttle flight. The Tracking and Data Relay Satellite (TDRS-3) was deployed in September 1988 to join TDRS-1 in providing low-Earth orbit operational support to space missions. TDRS-4 will be added to the geosynchronous satellite network in March 1989 (STS-29), bringing to fruition NASA's goal of a space-based tracking capability for low-Earth-orbit missions. TDRSS is critical to all future NASA Earth-orbiting missions, as well as to space missions government-wide. Work continues to provide operational support facilities as NASA initiates its highest flight rate for science missions.

Operational support has continued to approximately 20 unmanned missions. The Ground and Space Networks supported unmanned, near-Earth-orbiting satellites; deep-space missions; and balloons, sounding rockets, and aeronautical flight test programs. Data acquisition, data processing, communications, and control facilities were provided to Earth orbiters such as Nimbus, the International Ultraviolet Explorer (IUE), Active Magnetospheric Particle Tracer Explorer (AMPTE), and the Earth Radiation Budget Satellite (ERBS); Landsat-4 and -5; deep-space probes such as Voyager-1, and -2, Pioneer series, Phobos; and other NASA and international programs.

FY 1990 PROGRAM OBJECTIVES

The Office of Space Operations FY 1990 program consists primarily of continued operations of our support systems, and adherence to our plan for system upgrades which has been unchanged in scope but significantly lengthened in schedule, over the last four years.

The objectives of our FY 1990 program include:

- Assured tracking, communications and data support to flight programs;
- Increasing the space network reliability and assured availability through the implementation of the STGT to backup the White Sands Ground Terminal and the completion of the TDRS orbital constellation and the continued development of replacement spacecraft;
- Upgrading the networks to meet the requirements for advanced missions such as Galileo, Magellan, Ulysses, Mars Observer, Global Geospace Science (GGS), Collaborative Solar Terrestrial Research (COSTR), and CRAF/Cassini;
- Developing systems to meet space station era and other anticipated complex needs of future users of the Space Operations network.

These objectives will be individually detailed in the sections which follow.

As stated by Dr. Fletcher in his statement before this Subcommittee: "None of our space flight programs could meet their objectives without the availability of high quality, reliable space operations, tracking, and data support." The Office of Space Operations FY 1990 budget was established to assure that support now and in the future.

FY 1990 BUDGET REQUEST

Our FY 1990 budget request of $1122 million provides tracking, command, communications, data acquisition and data processing support to NASA flight missions.

Space Network program activities will require $582 million in FY 1990. This essentially provides for repayment of the loans to the Federal Finance Bank, TDRS Spacecraft production, continued implementation of the Second TDRS Ground Terminal (STGT), modernization of the current White Sands Ground Terminal, systems engineering, operations and maintenance.

The Ground Networks program activities will require $270 million in FY 1990. Funding for the Ground Networks provides for operation, maintenance, and engineering support of worldwide tracking facilities. Also included is funding to upgrade the Deep Space Network to meet requirements for the Ocean Topography Experiment (TOPEX), Mars Observer, GGS, COSTR, and CRAF/Cassini.

Communications and Data Systems program activities will require $250 million in FY 1990. This provides for the implementation and operation of facilities and systems required for data transmission, mission control, and data processing.

An increasingly vital program focused on assessing and employing technological advances in telecommunications, microcircuitry, and computer sciences is Advanced Systems requiring $20 million in FY 1990.

Of the total funding requested, 65 percent is required to operate and maintain in place tracking and data communications facilities and to repay the TDRS development loans. The remaining 35 percent provides for systems engineering and development for spacecraft, ground stations, computer systems and software.

SPACE NETWORK PROGRAM

The Space Network consists of Tracking and Data Relay Satellite System elements which provide tracking and communications to space missions. This network will be the primary system providing user science data and spacecraft control through the next generation of low-Earth orbital missions. Key elements of this network are: the in-orbit satellites; the White Sands, New Mexico facilities, including the existing White Sands Ground Terminal (WSGT) and the NASA Ground Terminal (NGT); and the Goddard Space Flight Center (GSFC) facilities in Greenbelt, Maryland, including the Network Control Center (NCC) and Flight Dynamics Facility (FDF).

As mentioned earlier, TDRS-1 has been joined in orbit by TDRS-3. These two satellites are currently providing continuing support to Landsat-4 and -5, the Solar Mesospheric Explorer (SME), and the Earth Radiation Budget Satellite (ERBS) and mission-duration support for Shuttle flights. TDRS-3 has been performing flawlessly, having completed its checkout sequence 30 days early, in time to provide ongoing support to the STS-27 mission launched in December 1988.

TDRS-4, scheduled for launch on STS-29 in March 1989, will replace TDRS-1 as the operational satellite in the east location. TDRS-1 has suffered significant failures since its launch in 1983 and is unable to provide a full complement of support services to user spacecraft. The spacecraft currently has only one forward link available for Ku-band support and due to the generic problem in this service, that link is expected to be lost within the year. With its reduced capabilities, TDRS-1 will be relocated to serve as the on-orbit spare until TDRS-5 can be launched to replace it. In April 1989, TDRS-1 will have used 6 of its 7-year design life.

In addition to the funding necessary to sustain routine operations and spacecraft production and deployment, funding is required to ensure the viability and availability of this resource.

In order to eliminate the White Sands Ground Teminal (WSGT) as a single point of failure in the network, the development of the Second TDRSS Ground Terminal (STGT) is underway. The prime contractor was selected in December 1988, concluding the competitive procurement process.

When operational, the STGT will function as a backup to the WSGT in the event of a catastrophic failure of the present system and during planned outages for major equipment repairs or changes to the existing WSGT. In addition, the STGT will provide for expansion of user services in the mid-1990's when current system capabilities will be exceeded by user demand.

During the STGT development, additional systems will be procured to replace the current WSGT systems with the inherently more reliable and technologically updated STGT equipment. This will provide long-term efficiencies in operations, maintenance, and engineering support of the White Sands complex and will significantly reduce life cycle costs. The FY 1990 request includes funds for these systems for the WSGT.

Development of the TDRS Replacement Spacecraft is also continuing under contract with TRW, builder of the current series of TDRSS spacecraft. This spacecraft, TDRS-7, will serve to replace the TDRS-2 lost in the Challenger accident.

During the mid-1990's, network support requirements will increase dramatically as Space Station Freedom, the Advanced X-Ray Astronomy Facility (AXAF), Space Station Polar Platforms, and other missions reach flight status and additional new missions are developed and deployed in space. Concurrently, the available inventory of TDRSS spacecraft will be exhausted as TDRS-6 and -7 are launched to replace the operational satellites reaching the end of their lifetimes.

These factors will necessitate replenishing the supply of relay satellites to maintain network viability in supporting all low-Earth orbital missions. To that end, conceptual design studies for the next generation of TDRS spacecraft are underway and are nearing completion. Competitive detailed design studies are planned for initiation late in the current fiscal year for this new satellite system, called the Advanced TDRSS (ATDRSS). As the development of an advanced relay satellite system will require nearly five years, it is imperative that appropriate steps be taken now to insure a sufficient supply of spacecraft are available to sustain network operations in the mid-1990's.

GROUND NETWORKS PROGRAM

The Ground Networks Program provides Earth-based tracking and data acquisition support services to all NASA science and engineering missions for spacecraft in high Earth orbit and in deep space. There are three separate programs: the Deep Space Network (DSN); the Spaceflight Tracking and Data Network (STDN); and the Aeronautics, Balloon and Sounding Rocket (AB&SR) program. The functions of each program are detailed in the following text.

DEEP SPACE NETWORK (DSN)

The DSN is a worldwide telecommunications network which provides tracking and data acquisition support to a variety of interplanetary and Earth-orbital spacecraft. The network has a world class capability for receiving transmissions from spacecraft operating in our outer solar system and for performing the extremely accurate measurements necessary to navigate a spacecraft to the outer planets. The DSN contains one of the largest planetary radar systems in the world, enabling scientists to map the surface of Venus, Mars, and Mercury and to observe the rings of Saturn, asteroids and comets. The primary elements of the DSN are three multi-antenna complexes positioned around the Earth at approximately 120 degree intervals of longitude to provide near-continuous observations of distant spacecraft. These facilities are located in Goldstone, California; Madrid, Spain; and Canberra, Australia. The network is managed by the Jet Propulsion Laboratory (JPL).

The most significant activities this year will occur in the operations area. The foremost challenge for the DSN will occur in August when the Voyager-2 spacecraft, which was launched in 1977, encounters the planet Neptune, over four billion kilometers distant. To receive the image and science data from the spacecraft at these distances, the DSN has been enhanced to increase its signal-gathering capability and sensitivity. This was accomplished by enlarging the 64-meter antennas to 70 meters in diameter and arraying (combining) the additional signal-gathering capabilities of other non-NASA large ground-based radio telescopes through a worldwide network. For example, the National Science Foundation's Very Large Array (VLA) at Soccoro, New Mexico, which is one of the most powerful radio telescope systems in the world, will be combined with the antennas at the Goldstone complex to receive the extremely weak signal emanating from the distant Voyager spacecraft.

The Magellan spacecraft, which is intended to study the planet Venus, will be launched in April. The Galileo spacecraft and its atmospheric probe will be launched to Jupiter in October. The Soviet Phobos mission, which is currently in orbit about Mars, is also being supported. A lander, placed on the Martian moon Phobos to help understand the dynamics of the Mars/Phobos system, will be tracked by the DSN. The landing is expected to occur in April 1989.

In FY 1990, NASA is requesting funds for DSN program operations activities and systems implementation. The DSN will continue tracking and data acquisition from the older Pioneer and Voyager spacecraft and, for the first time in a decade, will be supporting new planetary missions. In addition, the DSN will be preparing for the Ulysses, a solar research mission, scheduled for launch in 1990 and the Mars Observer mission in 1992. Sustaining activities for the network will continue with the replacement of an aging antenna subnet with three 34 meter diameter antennas capable of supporting existing missions and future requirements for increased mission flexibility and greater signal gathering capabilities. The planetary radar system at Goldstone will be enhanced by increasing the transmitter capacity to 1 megawatt which will improve the ability to study small asteroids by a factor of 10.

SPACEFLIGHT TRACKING AND DATA NETWORK (STDN)

The STDN is comprised of seven ground stations positioned around the Earth for low-Earth-orbit tracking and data acquisition from both manned and unmanned spacecraft. Two of the stations provide support for launch vehicles. The orbital and Shuttle support activities will be terminated when the TDRS space-based network becomes operational, which is anticipated later in 1989. The transition of orbital support activities to the Space Network will enable the majority of the STDN stations to be phased out. The network mission will then be to provide pre-launch, launch, and Shuttle landing support. The launch and operation of TDRS-4 will permit four stations to be closed: Ascension Island; Guam; Santiago, Chile; and Hawaii. The site at Dakar, Senegal, will remain to support Shuttle launches and will be closed when TDRS spacecraft are fully functional. The stations at Merritt Island, Florida, and Bermuda will be retained for launch support.

Plans have been in place for several years to close designated stations. Consistent with that planning, the following stations are scheduled for closure: Guam and Santiago on June 30, 1989; Ascension and Hawaii on September 30, 1989; and Dakar in 1991. These dates are dependent on the successful launch and checkout of TDRS-4. We are constantly reviewing our planning assumptions to assure viability of support capability in the 1990's.

The FY 1990 budget request includes continued operation, logistics, and implementation activities for the ongoing STDN to provide for pre-launch, launch, Shuttle landing, and other operational support. It also provides for activities associated with final network phasedown.

AERONAUTICS, BALLOON, AND SOUNDING ROCKET (AB&SR) PROGRAM

The AB&SR Program provides tracking, data acquisition and data processing support for suborbital research activities and tracking and data acquisition support to selected low-Earth-orbiting satellites. The program also provides Shuttle landing support at Edwards Air Force Base in California. Mobile and fixed instrumentation systems for tracking, data acquisition, and safety requirements for sounding rocket and balloon launches are managed and operated by the Wallops Flight Facility in Virginia. These systems support a worldwide program of scientific research. The telecommunications facilities at Wallops also support low-Earth-orbiter missions such as Nimbus-7.

In FY 1990, NASA is requesting funds for fixed and mobile operations activities and for systems implementation at the Dryden and Wallops facilities.

COMMUNICATIONS AND DATA SYSTEMS

The basic elements of the Communications and Data Systems Program form the vital link between data acquisition stations. These functional elements include: communications; mission control; and data processing, which includes data capture, first-order processing, and data distribution. Some development activities, such as the Customer Data Operating System (CDOS), span many or all of these functional elements. National and international coordination of the entire electromagnetic spectrum of radio and communications to prevent radio or electromagnetic interference with mission support is also an important facet of our responsibilities. Each element of the program will be detailed in the following text. This program in 1989 and 1990 achieves its almost exclusively operational character from the return-to-flight of Shuttle and other missions, and it is beginning to work off the backlog of flight missions.

COMMUNICATIONS

The Office of Space Operations Communications Program provides all Agency-wide communications services for operations needs, through the NASA Communications (Nascom) Network, and for non-operations administrative functions, through the Program Support Communications Network (PSCN). These global systems interconnect NASA foreign and domestic tracking and data acquisition stations; launch areas; mission and network control centers; and support installations, including field centers, major contractors, and investigator sites.

In Nascom, we will continue into FY 1990 with a fully-activated complement of communications circuits for all Shuttle flights, supporting launch, on-orbit, landing, and post-landing operations. Plans are underway for support to far and near encounters of distant planets. We are in the midst of engineering and implementing a five-year communications capability upgrade designed to support the higher data rates and volume requirements placed on the DSN. At GSFC, equipment replacement and modernization will continue, with emphasis this year on the message switching computational facility. Communications interconnection of the STGT and existing White Sands tracking facilities will also be initiated in the coming fiscal year. Definition work and studies will be completed for the augmentation and upgrade for the new era starting in the mid-1990's, the era of ATDRSS and Space Station Freedom support.

Effective use of the integrated, all-digital PSCN has continued to expand, serving the Agency voice and data requirements for institutional and programmatic matters. In FY 1990, the PSCN will continue to support NASA programs and projects, such as the Space Shuttle, Space Station Freedom, and science users. NASA-wide video teleconferencing capabilities will also be expanded to increase accessibility and to economically support additional users.

MISSION CONTROL

The Mission Control Program provides systems capability to command and control NASA unmanned low-Earth-orbiting scientific and applications spaceflight programs. Payload Operations

Control Centers (POCC) receive, process, and display spacecraft telemetry data and transmit spacecraft commands. Related Command Management facilities interface with the user community to generate mission plans and to prepare command loads for the POCC/user spacecraft uplink.

Continued Mission Control support includes operational control of seven orbiting spacecraft and the development of systems to support future missions. Two of the Great Observatory spacecraft, the Hubble Space Telescope (HST) and the Gamma Ray Observatory (GRO), will be launched in FY 1990, adding to the command and control workload.

The HST will be controlled from the HST-specific POCC at Goddard, developed to execute the extensive science-gathering workload already planned for this orbiting telescope. The GRO will be controlled from the Multi-Satellite Operations Control Center (MSOCC) which will continue controlling three currently orbiting spacecraft and the Cosmic Background Explorer (COBE) set for launch later this year. At the end of FY 1990, five control centers will monitor and control 10 spacecraft. Provisioning MSOCC for future missions, such as the Extreme Ultraviolet Explorer (EUVE), the Upper Atmosphere Research Satellite (UARS), and the many individual missions of the Global Geospace Science (GGS) Collaborative Solar Terrestrial Research (COSTR), will continue.

DATA PROCESSING

Two separate activities are funded within the Data Processing Program: Capture and first-order processing of data from low-Earth-orbiting spacecraft for both scientific and applications missions; and the highly-specialized computational support for flight dynamics and attitude and orbit determination which occurs from earliest mission planning through real-time mission operations. These activities are discussed in the following text.

Data Processing support of in-flight missions continued through calendar year 1988. Software and hardware activities continue in the Data Capture Facilities dedicated to the Hubble Space Telescope and Gamma Ray Observatory missions. As long-delayed rescheduled launch dates draw near, commensurate data processing operations activity increases. The number and diversity of Spacelab flights in the next few years is far beyond any previous activities.

Telemetry data-processing support operations will continue for existing missions. New-mission support will be interleaved into current support structures as missions are launched. Space Station Freedom planning and study activities for data-processing support, especially for platforms, are also being pursued.

Flight dynamics support for free-flyer spacecraft and mission support for in-orbit spacecraft will continue, including support to the International Ultraviolet Explorer (IUE), International Cometary Explorer (ICE), Earth Radiation Budget Satellite (ERBS), and Dynamics Explorer (DE). Funding to upgrade real-time computational support capabilities for current and future missions is also part of the budget request. Flight dynamics systems analysis and software development continues for future mission support. In FY 1989, support for launch and mission operations will be extended to the Cosmic Background Explorer (COBE) and in 1990 to the Broadband X-ray Telescope (BBXRT) by the flight dynamics system.

Starting in the mid-1990s, much higher data rates and volumes will be experienced as space exploration continues to grow in complexity. Accordingly, ground support capabilities must expand and evolve to keep pace with requirements. In support of Space Station era activities, extensive studies and planning will be completed in 1990, followed by implementation. Emphasis is being placed on evaluation and application of data systems standards for Space Station Freedom and for all future flight programs.

ADVANCED SYSTEMS

The Advanced Systems Program is an essential part of the Office of Space Operations which provides systems and operational technology to sustain current state-of-the-art capabilities for the operational systems.

The objective of this activity is to study and develop new and improved tracking and data handling capabilities, which will address mission requirements and provide cost-effective and reliable tracking and communications support of future NASA missions.

Ongoing tasks include: investigation of the total data transfer and data processing needs of upcoming missions; studies of ground systems and telecommunications links to determine optimum design approaches; and overall trade-offs for the lowest life-cycle costs of operational systems to support future space missions.

In FY 1990, we will continue these activities to improve position location and navigation capabilities with measurement of position accuracy of Earth-orbiting spacecraft to the decimeter level. Radio frequency and optical technology developments will benefit future missions by allowing increases in the amount and quality of data returned by spacecraft. Other major components of the FY 1990 effort relate to data systems, control centers, and operational automation and autonomy. We will continue to develop advanced data storage, processing, and transmission techniques to match the needs of future, high-resolution, space-borne sensors as well as development of more efficient mission operations control center facilities with the provision of real-time interaction between ground-based experiments and their space-borne instruments. Finally, investigations will continue in the area of expert systems applications, greater use of distributed command terminals; and the performance of orbit and attitude computations on board the spacecraft.

The Office of Space Operations has begun to study the infrastructure and necessary operational support which would be needed for future exploration activities with the Office of Exploration. This includes identifying system architectures and trade-off recommendations up front, so the total life cycle costs of these programs can be understood beginning at the preconcept stages.

CONCLUSION

In summary, the long awaited operational Space Network is expected in FY 1989 when TDRS-4 joins TDRS-1 and -3 in geosynchronous orbit and provides support to space missions. Implementation of ground station closure plans for the Santiago, Chile; Guam; Hawaii; and Ascension stations is underway. The Deep Space Network is completing preparation to support the Neptune encounter of Voyager-2 in August 1989 as well as supporting the Magellan and Galileo planetary launches this year.

The FY 1990 request of $1122 million is essential to meet the 1990 era challenges on the horizon. These challenges include preparation for the TDRS-5 launch, continued implementation of the second ground terminal, completion of the mission control and data capture system required to support the Hubble Space Telescope, and continued network preparation for the Magellan, Ulysses, Galileo, and Mars Observer missions.

Our ten-year planning is focused on sustaining our Space Network by providing redundancy in the White Sands Ground Terminal, TDRS spacecraft availability, and upgrade in capability. The DSN will in the future add new network design capability and data rate advancement by increasing technology through the use of Ka-band, and the communications and data systems program is planning significant upgrades to provide support for the space station era. Along with launch capacity, operations capacity must provide the Nation with the overall capability for the conduct of space operations. To attain the flight objectives of the exciting programs NASA will be conducting in the next few years, the operations infrastructure must be sustained and supported. I urge the Subcommittee's full support of the Space Operations budget and also urge the Subcommittee's support of NASA's institutional program necessary to achieve these operational objectives.

Mr. Chairman, members of the Subcommittee, this concludes my statement. Thank you for this opportunity to discuss NASA's Space Operations Program with you.

Again, thank you.

Mr. NELSON. Let me just ask you right there, certainly this is what we have expected all along with regard to the budget, and that was one of the reasons for having TDRS and so forth and so on.

Are we sure that we are doing the right thing on the basis of past experience where we have had satellites go out of control that we could not communicate with via TDRS that we could communicate and restore through ground stations?

Mr. ALLER. Yes, sir, I believe we are on the right track. As you may know, about a year ago I asked the same question of our group to make sure that the path we were on is the right way.

Specifically, I asked what has changed since 1985, when we established the baseline that we are on. The only thing that has changed is that we have ELVs today and we planned to phase the expendable launch vehicles out in the 1985 timeframe before the *Challenger* accident.

It does affect the use of the Ascension Island project.

The other issue that came up was this one you mentioned of a spacecraft loses attitude control or loses control of its antenna, its pointable antenna, to TDRS. And we have one case of that in recent times.

We evaluated that with each of the program offices to determine what is their safe hold, what we called the safehold rule, to see if they have a problem, and what kind of a coverage do we have left. We have to remember we still have these Goldstone, Canberra, the Mila station at Kennedy, and the Bermuda station as well as Wallops.

With that coverage retained on the ground, at the three DSN sites, you recall, we have a 26-meter antenna, which is the old Apollo-era antenna, that is specifically for high Earth-orbit use, geosynchronous-type use. Altitudes above the capability of TDRS. However, it is used today for shuttle missions.

So, we have those five or six stations that will be available in that time. In evaluating this with the programs, the programs determine that they did not require the stations we are closing in the unlikely event that they would lose—either we would lose TDRS for a short period of time or they would lose their ability to point to TDRS without being able to recover the spacecrafts in one of the existing ground stations.

So, we have exhaustively looked at that, and it was a question I asked a year ago.

The other point on ELVs is that of course the Delta, the Titan programs, do use Ascension for tracking their upper stages with a launch down at the Ascension Island closes down at about 11 degrees south across the equator. So, it provides good coverage.

We have recently communicated with the Air Force's Eastern Test Range, and Colonel Gooch at ETR has indicated that the Air Force plans to pick up that station and will support the ELV users.

So, with those resolutions, if that develops and we can carry that out, that allows us then to phase out our activity at Ascension and the Air Force will pick up whatever support is necessary.

Mr. NELSON. Have you always planned, when you had the other TDRS up, that you could then to only phase those out but you were going to plan to keep the ones that you are keeping?

Mr. **Aller**. Yes, sir.

Mr. **Nelson**. Has that always been the plan?

Mr. **Aller**. Yes, sir.

Mr. **Nelson**. Those one, two, three, four, five, six? Six?

Mr. **Aller**. Yes, sir.

Mr. **Nelson**. Okay.

Mr. **Aller**. Are there any other questions regarding the station closure?

Mr. **Nelson**. Please proceed.

Mr. **Aller**. May I have the next chart, please (fig. 14)?

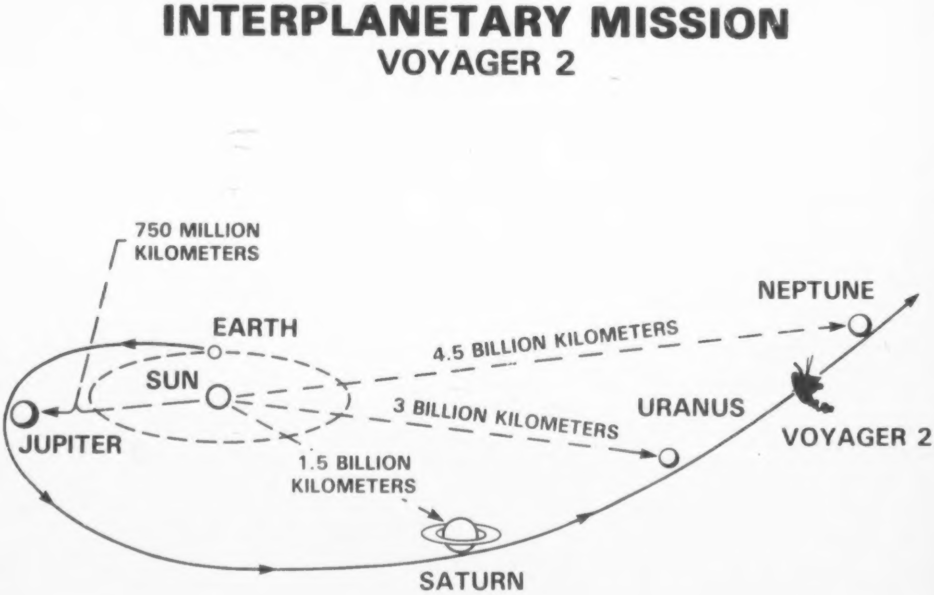

INTERPLANETARY MISSION
VOYAGER 2
750 MILLION KILOMETERS
EARTH
SUN
JUPITER
4.5 BILLION KILOMETERS
NEPTUNE
3 BILLION KILOMETERS
URANUS
VOYAGER 2
1.5 BILLION KILOMETERS
SATURN

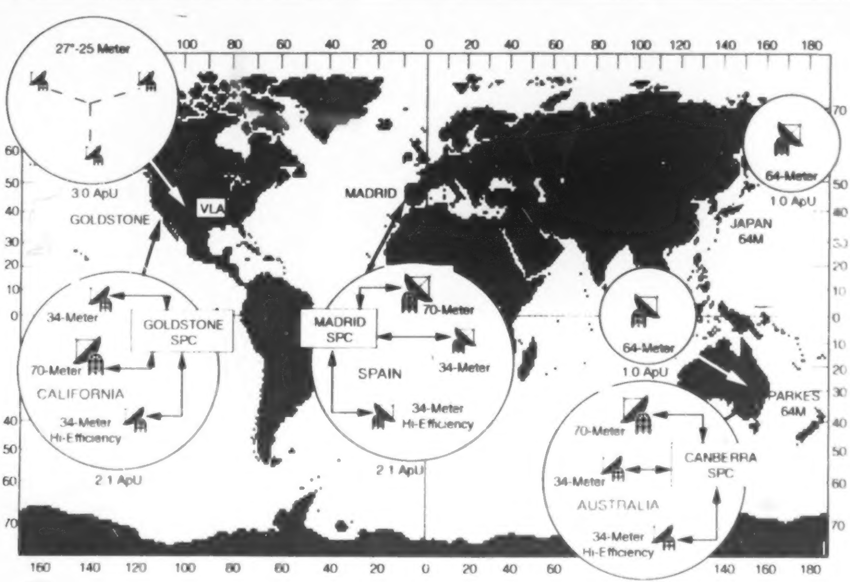
Figure 14

This is just a few viewgraphs I have inserted to highlight the encounter coming up in August. We have been working for several years to allow for that encounter. And the program, of course, (fig. 14) is the program started at Jupiter. Then we went to Saturn, then to Uranus, and now this summer to Neptune. And you can see the distances that have been involved.

From the standpoint of signal strength with the signal returning from the spacecraft, as compared to Jupiter, the signal strength is about 1/35th of what it was at Jupiter. It is about half of what it was when we were at Uranus in 1986.

So, what the ground network has had to do is overcome that loss of signal strength to enable us to receive the data rates necessary for imaging on the ground. And we have done that as we have talked before, as shown on (fig. 15) the chart on the right, which shows how we have arrayed our ground antennas together.

AUGMENTED DEEP SPACE NETWORK
FOR THE
VOYAGER - NEPTUNE ENCOUNTER


27*-25 Meter
3.0 ApU
GOLDSTONE
VLA
MADRID
64-Meter
1.0 ApU
JAPAN
64M
34-Meter
GOLDSTONE
SPC
70-Meter
CALIFORNIA
34-Meter
Hi-Efficiency
2.1 ApU
MADRID
SPC
70-Meter
SPAIN
34-Meter
34-Meter
Hi-Efficiency
2.1 ApU
64-Meter
1.0 ApU
PARKES
64M
70-Meter
CANBERRA
SPC
34-Meter
AUSTRALIA
34-Meter
Hi-Efficiency
2.1 ApU

○ NON-NASA RADIOTELESCOPES

NOTE: 1 APERTURE UNIT (ApU) - SIGNAL RECEPTION CAPABILITY OF A 64-METER ANTENNA

* 25 COMMITTED, 2.5 ApU

Figure 15

Rather than build one huge antenna, we have arrayed our ground antennas together with those in yellow, which are not NASA sites. One is an Australian site, one is a Japanese site, and the third one is the National Science Foundation site.

We have arrayed those to give us an increase at what we call aperture units on the ground where we're receiving strength, receiving margin on the ground.

We have completed that just recently, and this chart is an upgrade of the ones I have shown you previously because the performance of what we have exceeds what we have designed into the system.

The 70 meters performance is better than we had anticipated, and the array that I will show you in just a moment at Soccoro is also somewhat improved. We were predicting 2.5 aperture units, we are actually getting three out of those 27 antennas.

So, I believe the work that you have helped us with over the past years in putting this configuration in place is really going to pay off on this one-time event coming up in this summer.

Could I have the next two charts (figs. 16 and 17), please?

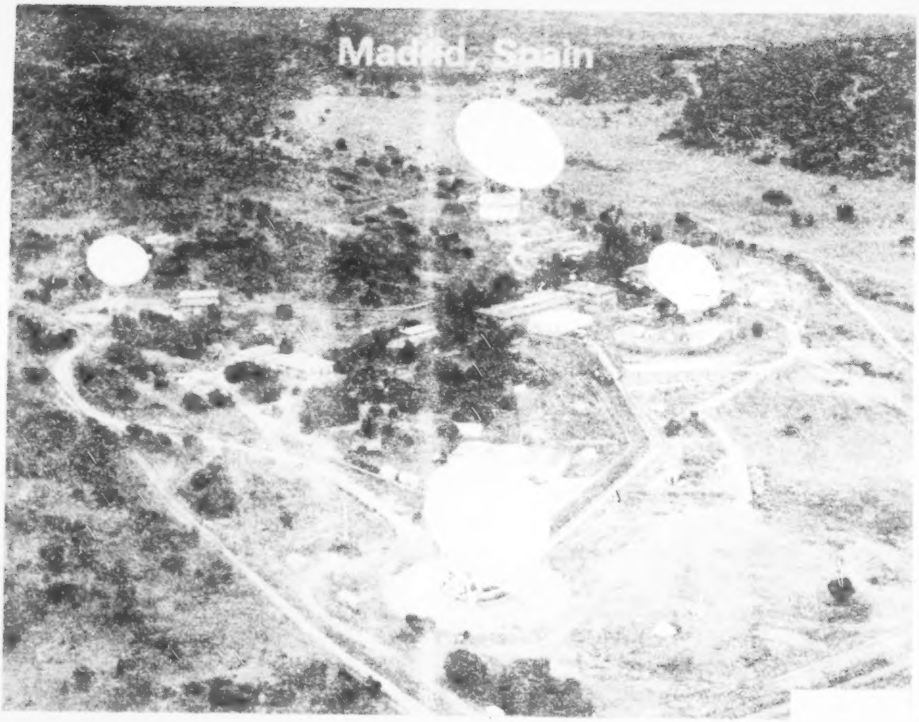

Madrid, Spain

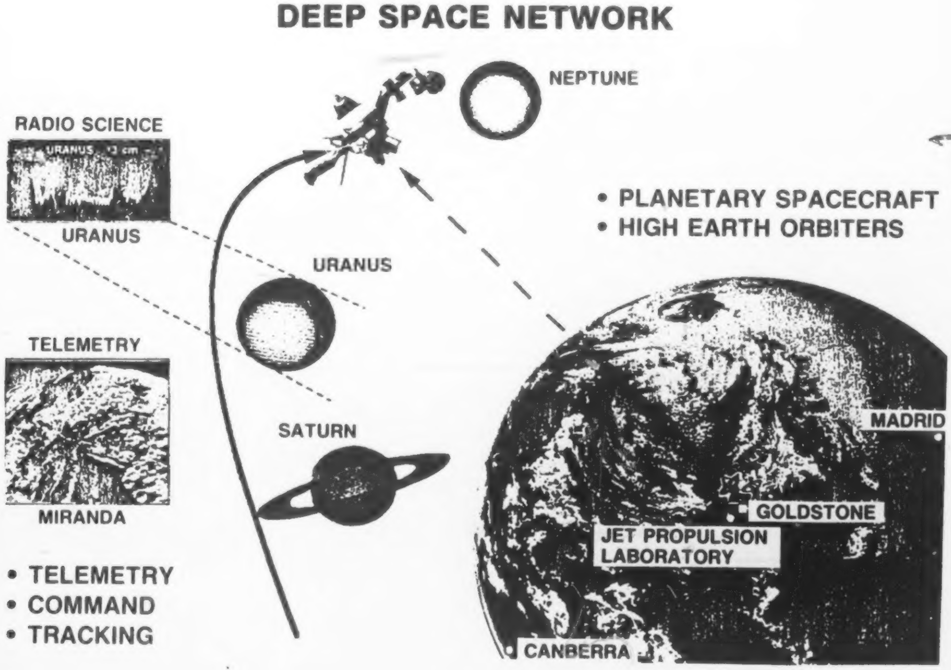
Figure 17

Very briefly, I have one slide of Madrid that shows the large antenna at the top. That is the new 70 meter with two 34 meters down below, and the 26 meter off to the left.

The chart (fig. 17) on your right is the Soccoro station in New Mexico. It doesn't show the entire station. It shows one leg of the Y, but there are 27 antennas that we utilize there, nine on each leg, that we effectively point at the spacecraft along with the Goldstone antenna and receive the signals simultaneously and combine electronically that signal to a signal return.

We have been activating—each of those 27 antennas we have modified at Soccoro. And I should say that modification has enhanced not only our work but the work of the National Science Foundation.

Next slide, please (fig. 18).



DEEP SPACE NETWORK

- PLANETARY SPACECRAFT
- HIGH EARTH ORBITERS

- TELEMETRY
- COMMAND
- TRACKING

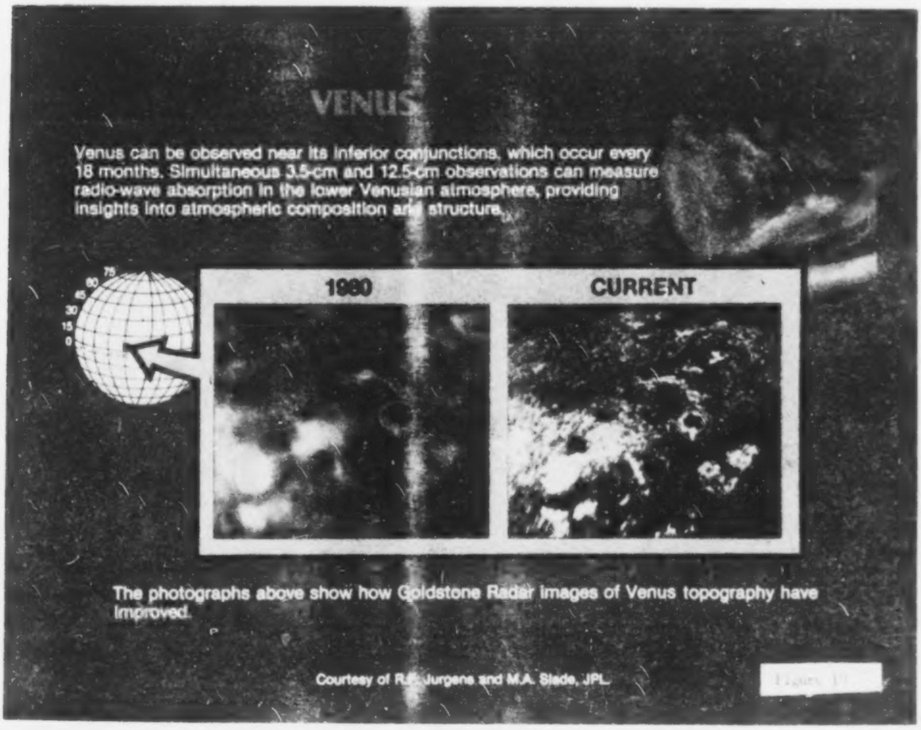
NEPTUNE
RADIO SCIENCE
URANUS 13 cm
URANUS
URANUS
TELEMETRY
MIRANDA
SATURN
MADRID
GOLDSTONE
JET PROPULSION LABORATORY
CANBERRA

Figure 18

And at Neptune the kind of data that we get is more than just talking to the spacecraft. As the spacecraft swings by Uranus, as well as receiving the telemetry for the video images that are shown in the little box on your left—this is data from the Uranus encounter—we also receive what is called radio science data which gives the scientists insight into the products in and around the planet as we swing by.

In the chart on your right, the DSN is also used as a radar, and we use it for radar mapping of the planets. Basically, we transmit a signal in the direction of the planet and receive the signal as a normal radar operation.

Figure 19 simply indicates from 1980 radar imaging Venus to 1986 the improvement that has been made at JPL. Most of that improvement—all of that improvement—has been on the ground in the processing of the returned signal.



VENUS

Venus can be observed near its inferior conjunctions, which occur every 18 months. Simultaneous 3.5-cm and 12.5-cm observations can measure radio-wave absorption in the lower Venusian atmosphere, providing insights into atmospheric composition and structure.

75
60
45
30
15
0
1980
CURRENT

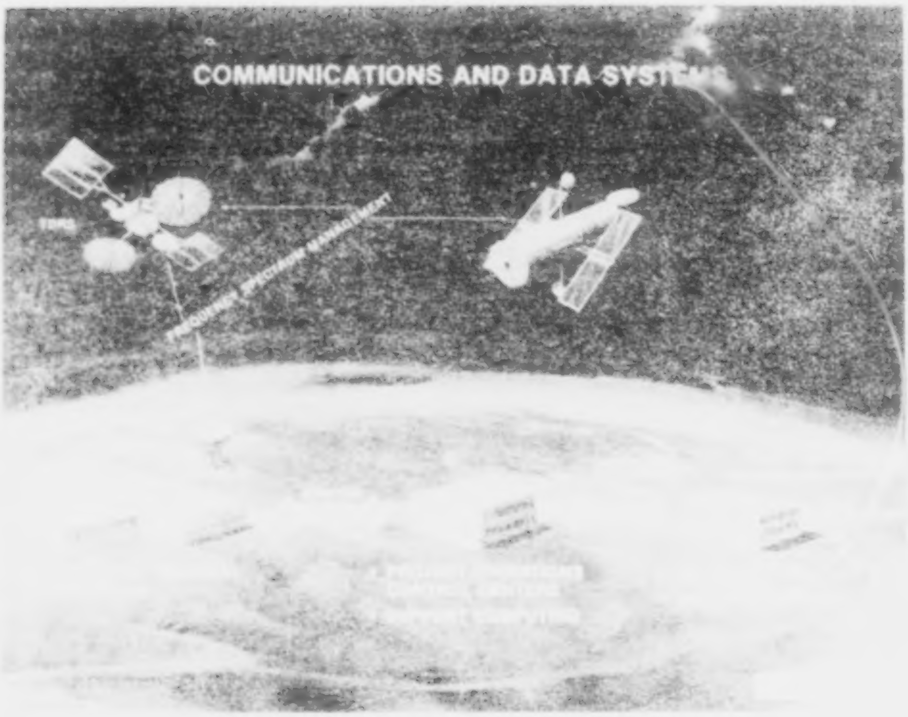
The photographs above show how Goldstone Radar images of Venus topography have improved.

Courtesy of R.F. Jurgens and M.A. Slade, JPL.

Figure 19

What we have in the 1990 budget is an upgrade of the radar itself. We plan to double the transmission power at the Goldstone radar.

Could I have the next slide, please (fig. 20).



COMMUNICATIONS AND DATA SYSTEMS

That is an exciting event this summer and one that I think the Nation should be very proud of.

Our last area is communications and data, which covers all the communications in the data processing and capture, data capture, for the ongoing mission. The only thing I will mention briefly here in our discussion—with the next slide (fig. 21), James——

CDOS Functions

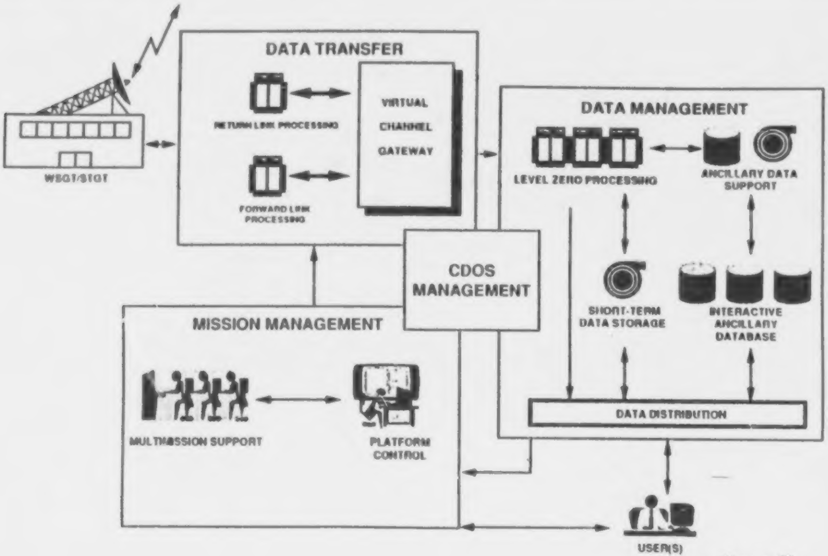

DATA TRANSFER
RETURN LINK PROCESSING
FORWARD LINK PROCESSING
VIRTUAL CHANNEL GATEWAY
WSGT/STGT
DATA MANAGEMENT
LEVEL ZERO PROCESSING
ANCILLARY DATA SUPPORT
SHORT-TERM DATA STORAGE
INTERACTIVE ANCILLARY DATABASE
DATA DISTRIBUTION
CDOS MANAGEMENT
MISSION MANAGEMENT
MULTIMISSION SUPPORT
PLATFORM CONTROL
USER(S)

Figure 21

Figure 21 is the upgrade we are providing for the space station era. The term that we use for this facility, which will be at the Goddard Space Flight Center in Maryland, is the Customer Data Operations System, and it consists of a very large system to receive the very high data rates that we are looking at in the late 1990s with the space station and the Earth science program.

It will have a capability to distribute the data from the White Sands Ground Terminal, then gobble up that data, and as well as control the platforms and manage the mission and transmit the data on to the users.

That facility will come on line now in about 1996, and we are starting it in the 1990 budget.

Another item I want to mention briefly to you in our discussions of the 1990 budget—next slide (fig. 22)——

Telemetry and Command System, Based on VLSI Technology

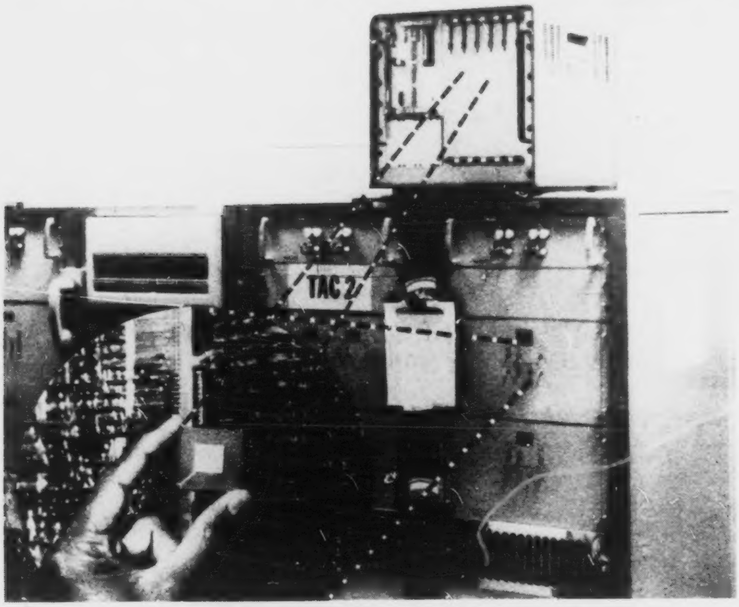


Figure 22 is our advanced R&D work, the small piece of the budget that we have, about $20 million R&D each year.

An example of the work that we do there is shown on this chart.

Basically, at Goddard we develop a chip, and the chip is shown in the man's hand. That chip replaced the drawer to the right, shown on the racks. And the box at the top has replaced all those racks of equipment below it. And that reduction is due to the advanced technologies that we are developing in our R&D budget have made that possible.

Next slide, please (fig. 23).

NASA

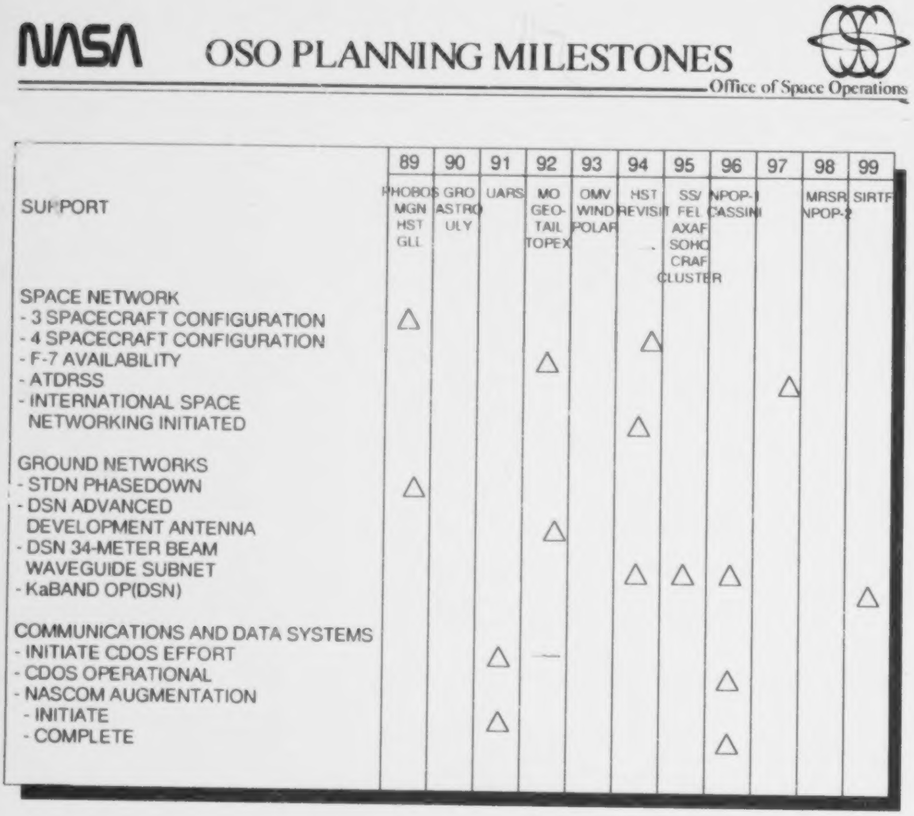
SUMMARY

MAJOR CHALLENGES

- OPERATIONAL SPACE NETWORK
- SUCCESSFUL LAUNCH AND CHECKOUT OF TDRS-4
- MAINTAIN VIABLE TDRS-7 SCHEDULE
- SUPPORT HUBBLE SPACE TELESCOPE AND GAMMA RAY OBSERVATORY
- IMPLEMENTATION OF SECOND TDRS GROUND TERMINAL AND WHITE SANDS UPGRADE
- SUPPORT TO PLANETARY MISSIONS AND VOYAGER/ NEPTUNE ENCOUNTER
- SPACE STATION SUPPORT ELEMENTS
- ADVANCED TDRSS (ATDRS)
- EARLY EMPHASIS ON COMMUNICATIONS AND DATA HANDLING NEEDS BY MAJOR PROGRAMS
  - SPACE STATION, EARTH OBSERVATION, EXPLORATION

Figure 23

In summary, then generally I would like to say that our challenges for 1990 are maintaining an Operational Space Network, a successful launch ahead of us next week, maintaining a viable schedule for the replacement spacecraft, supporting the Hubble Space Telescope, and the Gamma Ray Observer, implementation of the second ground terminal, support of the planetary missions and the encounter, space station support elements, the advanced TDRS, and the early emphasis that we are placing both with space station, the Earth observation program, and exploration on the need to consider the complex communications that are necessary for those programs.



NASA OSO PLANNING MILESTONES

Office of Space Operations

	89	90	91	92	93	94	95	96	97	98	99
SUPPORT	PHOBOS MGN HST GLL	GRO ASTRO ULY	UARS	MO GEO-TAIL TOPEX	OMV WIND POLAR	HST REVISIT	SS/ FEL AXAF SOHO CRAF CLUSTER	NPOP-1 CASSINI		MRSR NPOP-2	SIRTF
SPACE NETWORK											
- 3 SPACECRAFT CONFIGURATION	△										
- 4 SPACECRAFT CONFIGURATION						△					
- F-7 AVAILABILITY				△							
- ATDRSS									△		
- INTERNATIONAL SPACE NETWORKING INITIATED						△					
GROUND NETWORKS											
- STDN PHASEDOWN	△										
- DSN ADVANCED DEVELOPMENT ANTENNA				△							
- DSN 34-METER BEAM WAVEGUIDE SUBNET						△	△	△			
- KaBAND OP(DSN)											△
COMMUNICATIONS AND DATA SYSTEMS											
- INITIATE CDOS EFFORT			△	—							
- CDOS OPERATIONAL								△			
- NASCOM AUGMENTATION											
- INITIATE			△								
- COMPLETE								△			

Figure 24

The chart on the right (Figure 24) is simply to show you—and I won't go into it unless you have questions—that we have had in place in the Office of Space Operations, a plan for about three years. This plan is depicted on this chart.

The tactics of the plan, the timing of the plan, of course, changes based on the budget. But this kind of an upgrade or capability we have had in place to meet the mission model that is shown on the top of the chart for two or three years.

Very basically, it shows the growth of the TDRS system and the Space Network. It shows the phasedown of part of the ground network, replacement of some of the 34 meter antennas under the JPL system, and a major conversion to the KA band system out in the late 1990s for the Mars sample return program. And lastly, under communications and data, the major upgrade I just talked about for the space station era.

Next two charts, please (figs. 25 and 26).

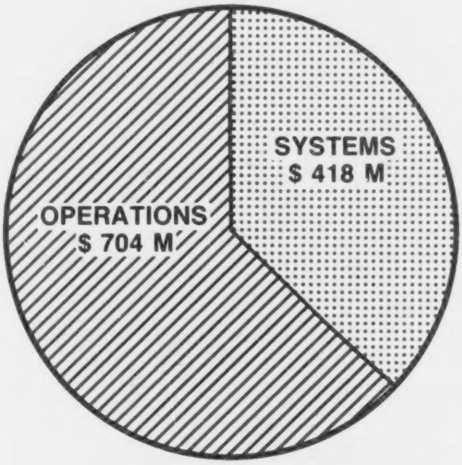
SPACE OPERATIONS PROGRAM

FUNDING REQUIREMENTS
(IN MILLIONS OF DOLLARS)

	FY 1988 BUDGET	FY 1989 BUDGET	FY 1990 REQUEST
SPACE FLIGHT CONTROL AND DATA COMMUNICATIONS			
o SPACE NETWORK	$ 433.4	$ 483.9	$ 582.3
o GROUND NETWORKS	231.0	228.1	269.6
o COMMUNICATIONS AND DATA SYSTEMS	215.0	233.3	250.2
SUB-TOTAL	$ 879.4	$ 945.3	$ 1102.1
RESEARCH AND DEVELOPMENT			
o ADVANCED SYSTEMS	$ 17.9	$ 18.8	$ 19.9
TOTAL	$ 897.3	$ 964.1	$ 1122.0

Figure 25

FUNCTIONAL COMPOSITION OF OSO FY 1990 BUDGET



TOTAL $ 1122 M

Figure 26

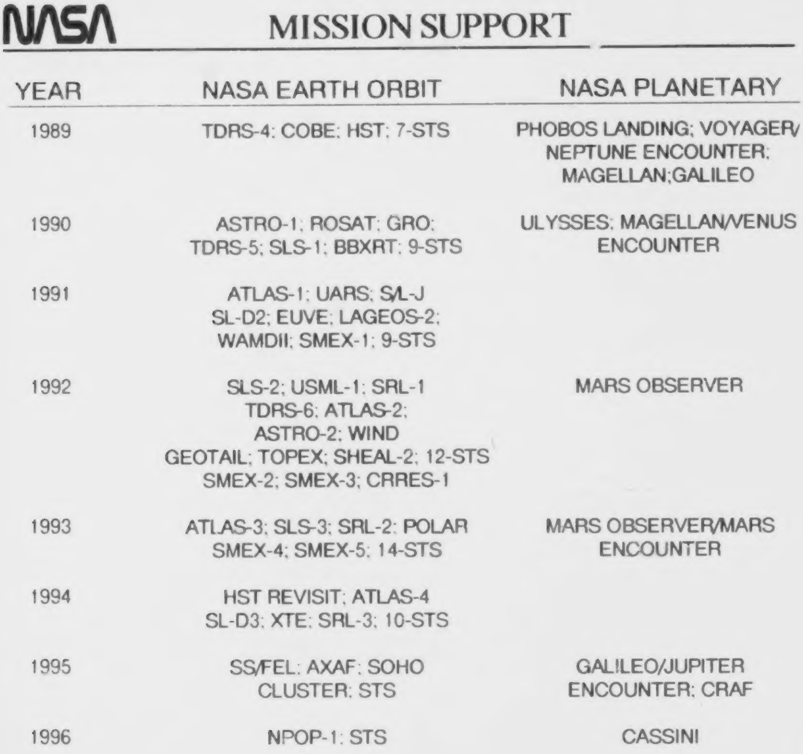
Finally, Mr. Chairman, I am getting to the budget. I have two budget charts, one that shows our request for 1990.

Mr. **Nelson**. Right.

Mr. **Aller**. And it indicates on the right that a little over $700 million of this goes into operations; the remainder goes into the systems upgrades, as I discussed earlier.

That piece of the budget represents about 8.4 percent of the NASA budget. I should say that the Office of Space Operations budget since 1970 has varied from about 8.0 percent to 13 percent of NASA's budget.

Finally, if I could have the next chart, James (fig. 27).



NASA MISSION SUPPORT

YEAR	NASA EARTH ORBIT	NASA PLANETARY
1989	TDRS-4: COBE: HST: 7-STS	PHOBOS LANDING; VOYAGER/ NEPTUNE ENCOUNTER; MAGELLAN;GALILEO
1990	ASTRO-1: ROSAT: GRO: TDRS-5; SLS-1: BBXRT: 9-STS	ULYSSES: MAGELLAN/VENUS ENCOUNTER
1991	ATLAS-1: UARS: S/L-J SL-D2; EUVE; LAGEOS-2; WAMDII; SMEX-1; 9-STS	
1992	SLS-2; USML-1; SRL-1 TDRS-6; ATLAS-2; ASTRO-2; WIND GEOTAIL; TOPEX; SHEAL-2; 12-STS SMEX-2; SMEX-3; CRRES-1	MARS OBSERVER
1993	ATLAS-3; SLS-3; SRL-2; POLAR SMEX-4; SMEX-5; 14-STS	MARS OBSERVER/MARS ENCOUNTER
1994	HST REVISIT; ATLAS-4 SL-D3; XTE; SRL-3; 10-STS	
1995	SS/FEL: AXAF: SOHO CLUSTER: STS	GALILEO/JUPITER ENCOUNTER; CRAF
1996	NPOP-1: STS	CASSINI

Figure 27

Why do we do this and why do we spend this money? And I think that is why. We have a very complete program of missions ahead of us through the year 1996. And our work as a support organization is in support of those missions.

Thank you very much. I ask for your support of this program. And I should mention also I would encourage the support of our R&PM budget that are necessary to conduct these programs. Within our program we support about 6000 contractors, and we have a little over 600 civil servants involved in our work. And the R&PM budget, of course, is a major effort for our civil service support in maintaining the program.

Thank you very much.

Mr. **Nelson**. Thank you, Mr. Aller.

I want to ask Mrs. Morella if she would take some questions for the committee. I need to step outside for a moment to consult on another matter, and I will be right back.

Mrs. Morella?

Mrs. **Morella** [presiding]. It is a great honor for me, I tell you. Just let the record show. [Laughter.]

Mr. **Nelson**. I will refer to you as Madam Chair.

Mrs. **Morella**. Thank you very much.

Yes, let's see. Do we have a quorum here? [Laughter.]

Mrs. **Morella**. Thank you, Mr. Aller. I really appreciated the charts and the explanation that you gave us in terms of where we're going in terms of mission support.

I notice that OMB deleted $111 million from your budget request for FY 1990. What is the effect going to be of that? Can you handle it?

Mr. **Aller**. Well, yes, it was a pretty heavy cut. It is by far the most severe cut I have ever experienced with them.

I can describe where I made those cuts and the effect will be.

Mrs. **Morella**. And what the effect is going to be.

Mr. **Aller**. The major portion of the cut is taken in the space network. Basically, it was such a large cut. What I said was I really can't reduce any of the ongoing support over the next 2 or 3 years. I had to look to the future to take out the advanced systems we have because in my business I simply can't cut back on what we are doing day to day in the support of programs.

So, I had to cut $25 million out of the replacement spacecraft and $25 million out of the STGT, both of which are vital to us in the mid-1990s. Any time we cut ongoing programs we simply add the money in at the tail end with escalation. And our experience is it doubles in that time for the money taken out.

I also reduced the ground network about $30 million. And of that, mostly it was taken out of advanced work we are doing for CRAF/Cassini, which is a new start in 1990 for the future.

The intent, of course, on those things—I call them deferrals, not cancellations—these are the things that we have to get done, but the only option I have was to move them into the out years.

And I took some—I reduced the money we had in for the space station support and delayed that program one year.

So, the effort that I am putting at Goddard to support the space station I delayed a year as a result of this cut.

Mrs. **Morella**. Do you meet with OMB when these decisions are made about where the cuts should come from, and do you defend——

Mr. **Aller**. Well, the agency meets with them. All of our—I think we had a full discussion of what the impact would be. And unfortunately, we are all working with the bottom line, and the only option I had was to cut out of the future.

Mrs. **Morella**. Thank you, Mr. Aller.

I am going to give my colleagues an opportunity to pose any questions they may have. So, before I turn this over to Mr. Sensenbrenner—Mr. Sensenbrenner, did you notice I am temporary Chair? [Laughter.]

Mrs. **Morella**. We can let you take over after I recognize the gentleman from Missouri, Mr. Buechner.

Mr. **Buechner**. Mr. Aller, thank you very much for being here.

I know that originally when the Office of Space Operations was established, the long-range projections were that it would take over not only data and tracking systems but also manned systems such as shuttle and space station.

I guess the question is does NASA still plan on the Office of Space Operations assuming those responsibilities of the shuttle at some point?

Mr. **Aller**. Mr. Buechner, when my present office, which at one time was the Office of Tracking and Data, was effectively renamed the Office of Space Operations, I was given the task by Dr. Fletcher to study some recommendations that were made by General Phillips that had to do with consolidation of operations.

And I did that over a year's period. As a matter of fact, the report was submitted to Dr. Fletcher a year ago November.

What I was really asked to do was study what is practical in NASA, given where we were, and what kind of an option could I come up with or could a task force be formed to come up with to perform that or to recommend some consolidations.

What we actually recommended was not pulling all these elements into this office, but rather we recognized that the focus for manned flight operations existed in our present office of space flight, Admiral Truly's office.

Admiral Truly's office is largely operations. Basically, he is conducting the launch operations. He has some development and some future development, but largely it s operations.

The task force recommended that we take the space station operations and shuttle operations or manned operations, consolidate those into the Office of Space Flight and make that a consolidated operation and do the initial space station planning from within the Office of Space Flight.

We recommended following recovery at some future time, with the new Administrator, to phase my office, the Office of Space Operations, into that function as well, such that we had all of our operational elements, the manned operation and my operation, under a single organization.

That recommendation was made to Dr. Fletcher, as I said, in April of last year. It was reviewed with the affected parties. I believe NASA's feeling at that time was we were very close to the shuttle recovery. Dr. Fletcher didn't want to make so many changes that would affect the shuttle recovery. And he put the recommendation on hold. And that is where we are today.

Mr. **Buechner**. Well, then I think it would be safe to assume that since that is on hold, it doesn't look like there is, however, any timeline to go the other way, which would be to put those things under space operations aegis.

Mr. **Aller**. No, there is none.

Mr. **Buechner**. Okay.

Mr. **Aller**. That's correct.

Mr. **Buechner**. And the same thing would apply, even though the ELV is, I guess, at a mature stage, now, there is no time frame to do that either; is that right?

Mr. **Aller**. Well, the ELV, of course NASA now no longer buys the ELVs and conducts the ELV mission. We buy mission services.

That part of the program already lies within Admiral Truly's organization.

So, they are together with the shuttle operations.

Mr. BUECHNER. I think I would yield back my time.

Mr. NELSON [presiding]. Any further questions?

Mr. SMITH. Mr. Chairman, I don't have any questions. But I would like for the record to show that in your absence the acting chairman served with distinction. [Laughter.]

Mr. NELSON. Well, that goes without saying.

Mrs. MORELLA. I thank the gentleman from Texas.

Mr. NELSON. Why don't you share with us something of the experience of the off-budget financing of TDRS? And make it brief and make it clear and to the point on the lessons learned about off-budget financing.

Mr. ALLER. I think I can make clear the lessons learned in the area of the TDRS program.

Off-budget financing was the term that has been applied to TDRS as a result of the commercial development of the program wherein the contractor with NASA's help, with the Government's help, obtained a loan from the Federal Finance Company to finance the development of the program.

Our payments began when we began service in 1983 and have been paying back the bank as well as the contractor at that point in time.

I believe, and I have a briefing I have given your staff and others, that the financing from the FFB worked extremely well. It was managed well. Our oversight of it went well. And it generally served the program very well.

I think one lesson I would like to emphasize to the committee is the concept that we had for the tracking data relay satellite has been proven successful. And we were talking about it earlier. It's operational and it's doing its job.

The lessons learned, as we saw them with the contract, both the commercial side as well as the nature of the contract, were that in the original concept it was a good concept, a viable concept. There was a commercial market, there is a commercial market for communications satellites. And that was very important to the proposal at the time.

So, with a single vehicle they could provide a commercial service and separately provide a Government service. And that was the idea.

They were going to develop it, and when they could not get the private financing without a full-faith-and-credit letter from the Government is when the Government had to back the loan and proceed. And that was done with the full understanding of the Congress, OMB, and NASA.

I think the problems we ran into in the program was the scenario that most of us are familiar with. One of the difficulties and one of the lessons is that the Government committed to provide the capability to enable the service in the first place. Basically, we would launch it once it was developed.

The difficulty we ran into, we were also developing shuttle and we were developing the IUS simultaneously. And as you know, neither of those were on schedule, so we have had considerable delays with the program, putting the program in place.

Those delays have been very costly not only to us but to the commercial side as well. The commercial program was built around an early KA band capability and a rather old technology in C band, and as I pointed out yesterday to your staff, the original concept was the fourth spacecraft in orbit would be the commercial satellite.

Well, we are not there yet, and we won't be there until the early 1990s. So, whereas the commercial contractor was looking for a spacecraft in the 1980's, he still would not have one.

So, what happened was the Government became responsible for not enabling the system due to the delays in the launch capability. We had a fixed-price contract. The fixed-price contract for lease services was not a good contract with an R&D development program, which is what this program was.

The technology is not new. But the system is new. I define it as system technology versus component or element technologies.

Further, we had changes. We had major requirements that entered the system after we initiated the program. We have major users that became users of the program that were not envisioned as users when we started. And therefore, we had to break in the fixed-price contract quite often.

So, I would say the key problem, key lessons were the commitments the Government had to make to put the system in place, the problem with enabling the system due to the delay of other systems that will be coming along simultaneously, were some of the key lessons that we learned that I think we are now attempting to apply as we look at other programs.

Mr. NELSON. Mr. Aller, does it not concern you that you have a bill coming due now every year in excess of $220 million, or what is it, about $227 million?

Mr. ALLER. Yes, sir.

Mr. NELSON. Every year?

Mr. ALLER. It concerns me very much.

Mr. NELSON. Do you think that is the best way to finance the activities of Government?

Mr. ALLER. I believe, and I believe we can show, that in some cases leased services where effectively you're paying for the money as well as the service the contractor has used, is a viable way to proceed.

We use leased services every day. A great deal over, I would say, $70 million in my budget goes into leased services for space—I am leasing space capability to communications satellites. All of our communications are leased.

I think the lesson is existing technology, existing systems, or systems that are not key to your main line activity. With TDRS, where we are so vital to the other programs in the conduct of NASA's missions, we could not afford to stand by and let the program not be developed with the robustness that is needed to assure its availability for the remaining programs.

Mr. NELSON. If you had to do it all over, would you do it the same way?

Mr. ALLER. I believe that with what we have learned, as any program that I have been in, that we could do it a heck of a lot better the second time around.

I believe with the lessons we have learned and taking them back to the timeframe that we were in, that we should have been able to predict that there would have been problems in the scenario we had to follow.

However, that is hindsight.

Mr. NELSON. So, is that answer a yes or a no?

Mr. ALLER. I believe that starting from today with the TDRS program that perhaps it could be made viable.

Mr. NELSON. So, your answer is yes?

Mr. ALLER. I would prefer not to manage it.

Mr. NELSON. I still don't know what your answer is.

Mr. ALLER. I think that what I am trying to get to is I think first of all I very much support commercialization in space. I think you very carefully have to select the program to make it viable. You have to know what you're buying, and you have to know how it fits into your system.

I believe today we have a launch capability, we have an upper stage, we know exactly what we want. I think starting today, we could proceed with this type program.

With a brand-new program, depending on its technology, depending on its use and its need, I think some of them would be a lot more difficult than others.

Mr. NELSON. So, you would proceed with this kind of financing arrangement in the future, or you would not?

Mr. ALLER. I believe I would.

Mr. NELSON. So, the answer is yes?

Mr. ALLER. From the financing standpoint.

Mr. NELSON. That is what my question was.

Dr. Smith, would you come in just a moment?

[Pause.]

Mr. NELSON. The next question is is the financing arrangement the right way to proceed, in your opinion, with something that is integral to the system?

Mr. ALLER. I presume that means with a fixed price, which is, I think, key to the issue, and a date-certain availability.

I believe that if it is key to the services that NASA has to render, the concern NASA has is will it be available, safely available in the time frame it needs it and will it provide the service that is needed.

It's not clear to me that the question of how it's financed is key to that. It may be I may be missing the point, but it is not clear to me.

Mr. NELSON. Well, take, for example, the telerobotic service—what is the name of it—flight telerobotic service on the space station. There is a proposal and we have had horrible experience financing with what you said. I asked for your statement to be concise, and it was anything but that.

Now, we have to make a choice on this decision, and we are trying to learn. Can you give us the value of your opinion?

Mr. ALLER. I think it would be difficult to proceed with FTS in the manner in which we proceeded with TDRS.

Mr. **Nelson**. And what is the difference there, in your judgment?

Mr. **Aller**. Well, I am of course much more familiar with what we have done in TDRS than what is the FTS program. But effectively, if it is key to NASA's operations in space, and I presume by its nature it is, I believe that the control the Government must exert on the development of that is similar to what we felt was necessary in TDRSS. And I believe it is certainly an R&D development. There will certainly be changes. There will be growth. There will be modifications. It is faced with some of the same complexities that we had to undo the commercial aspect in the way the program was financed with TDRSS.

So, I believe with a brand-new thing, starting from scratch, that is key to the ongoing program within NASA, it would be very difficult to pull that kind of a program together.

However, I think we have learned some lessons that we could structure the contract much more in favor of the Government, allowing for some of these lessons, than we have in the past. That is why, of course, we are going through the exercise to make sure that the TDRSS lessons have been exposed to those who would manage those programs.

But I think it would be very difficult.

Mr. **Nelson**. When was the contract set on the TDRS experience, on the financing?

Mr. **Aller**. When was it signed? In December of '75.

Mr. **Nelson**. I'm sorry? What?

Mr. **Aller**. December 1975.

Mr. **Nelson**. 1975.

Mr. **Aller**. That's when the contract started.

Mr. **Nelson**. Did you have anything further?

Mrs. **Morella**. Yes.

I just wanted to ask you, Mr. Aller, do you have enough personnel to be able to handle your data at Goddard? You've got a lot of data that is going to be pouring into Goddard.

Mr. **Aller**. Ms. Morella, we are very tight at Goddard. The personnel situation at Goddard is very tight.

Dr. Townsend, who runs that center, has been concerned about the amount of data. Therefore, since a great deal of my support comes from Goddard, I can't—we have been limited by the number of people he has been able to devote to my program.

Mrs. **Morella**. What is causing the limitations? Can you give some reasons?

Mr. **Aller**. Well, we are limited in the R&PM budget that we have to operate within, and therefore we are limited by the total number of people, civil servants, that each of the centers can hire. That is our limitation we are operating under at Goddard.

Mrs. **Morella**. So, it isn't that there is a numerical limitation on the number that you can hire, it's a monetary limitation on the money that you have to spread out to get the people you need at all levels? All levels?

Mr. **Aller**. All levels. All levels in NASA. I think the money determines the number.

Mrs. **Morella**. Yes. What are you doing about it?

Mr. **Aller**. Well, we are trying to—I believe that Dr. Hinners will have a hearing with you on the R&PM budget, and he is trying to enhance that progress so that we can solve some of these personnel problems we have had since the last several years.

They are very acute at Goddard. Goddard, as you know, has a real spectrum of programs. A great number of our key programs. And I will say some of them are spread rather thin through the management of the programs, and the TDRSS program happens to be one of those that has been affected by that limitation.

Mrs. **Morella**. Is it within your purview for you to get some information to this subcommittee on the critical personnel situation?

Mr. **Aller**. Certainly.

Mrs. **Morella**. All right. Thank you.

Thanks, Mr. Chairman.

Mr. **Aller**. I would be happy to provide that.

Mr. **Nelson**. Thank you, Mr. Aller.*

Dr. Rosen?

STATEMENT OF DR. ROBERT ROSEN, DEPUTY ASSOCIATE ADMINISTRATOR, OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. **Rosen**. Thank you, Mr. Chairman.

Mr. **Nelson**. Well, why don't we just do things a little differently here, and why don't we just start talking, and you can fill in as you would like to.

Why don't you tell us about some of this management stability problem.

In the last 20 years you have had 21 Associate Administrators. What is going on?

Mrs. **Morella**. That's a neat way to start.

Dr. **Rosen**. Well, Mr. Chairman, I think it is a serious problem that we have. The Associate Administrator level is the person who sets the policy for what we do in OAST, and he is the person who really sets the major direction of what we are doing in the programs.

I think it is very important that we seem to have the turnover that we have at the upper levels, and I think of any position at OAST that is the most crucial. We just seem to have that problem.

And I think that is related to several aspects. Part of the issue has to do with the pay to the Associate Administrator. We have had—I have had some personal discussions with some people who have been in that position, and basically if there is a level of a factor of two or three in pay between what somebody can get who works as Associate Administrator in OAST and what he can get on the outside. And you know, we have had this parade of people who come.

Mr. **Nelson**. Yes. No doubt about it, and that needs to be corrected, and it needs to be corrected in a rapid order or else we are going to have the continued brain drain all over the Government, not just in NASA.

But let's go beyond that issue. Here we have got one of the most important offices in NASA. This is our future. This is the research.

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*Appendix 3 contains additional answers to questions asked of Mr. Aller following this hearing of Mar. 7, 1989. See p. 1144.

Now, what's going on that we get this rapid turnover?

Dr. **Rosen**. In addition to the pay, Mr. Chairman, part of the difficulty has to do with the fact that it is a very exciting job, but there are exciting jobs outside. And you know, I haven't been in the position, I don't know what goes on in everybody's mind who sits there and moves on.

But the fact is that we have had people who have been attracted away from us. We have had people that we have brought in on a temporary basis, and I think that adds to the overall turnover.

We had somebody from a university a few years ago who was going to go back to the university. And the purpose of bringing him in was to get the new ideas and the new blood. And that is very important, but we also need some stability, and I think we are looking for the combination.

Mr. **Nelson**. Yes. Dr. Colliday was one of the longest tenures. He was here about three years.

Dr. **Rosen**. That's right. Right.

Mr. **Nelson**. Okay. Let's—well, I don't know. Members, do you want to ask any question about this? I am frustrated because here we are talking about Pathfinder, we are talking about CSTI, we are talking about basics, the near Earth research, CSTI, we're talking about Pathfinder, developing the technologies to take us way out in the solar system.

The Administration asked for last year $100 million. The Appropriations Committee gave them $40 million.

What is your request this year?

Dr. **Rosen**. $47 million.

Mr. **Nelson**. How much?

Dr. **Rosen**. $47 million.

Mr. **Nelson**. $47 million. You know, that's paltry.

I should say this is—I just gave a big speech about us establishing vision, setting a long-range goal that only the President can set. If we are going to do it—and I suggested what that goal should be: humans to Mars in an international mission.

If we are going to do anything like that, we've got to start right now. And we are not beating up on you, because you are just here as the messenger and you are the deputy.

But this reminds me like the new Administration, the first appointment in the new Administration after the Secretary of State ought to be the Science Adviser and the NASA Administrator because the future of this country is science and technology. And yet they are always the last.

So, I am not beating up on you. We are just venting some frustration.

Dr. **Rosen**. I understand that, Mr. Chairman. And frankly, I think the agency and the Administration is frustrated with the Pathfinder as well. I would like to have seen the budget be larger. And I know the Administrator would like to see the budget be larger. And I believe the same is true with OMB.

But the overall difficulty is the matter of priorities within the agency and the Administration.

Mr. **Nelson**. Excuse me for interrupting, and I don't mean to be, but I need to get this thought out.

What is happening to you is the same thing that happened in th private sector in corporations. The first place to cut budget is R&D Yet, that ought to be the last place to cut the budget.

Dr. Rosen. I certainly agree with you, Mr. Chairman.

Mr. Nelson. I know you do. And we are giving you support.

Mrs. Morella. Yes.

Mr. Nelson. I understand that.

Dr. Rosen. But let me point out in defense of what the agenc did, that we have a 14 percent growth in the space technolog budget this year. We have had significant growth in our budgets i the last couple of years. We were, throughout the '70s, we were les than two percent of the agency's budget. And we have had a significant increase in the past three years with the CSII and Pathfinde and the In-Space Technology Experiment program that we ar doing this year.

So, it is not like the space technology budget is completely bein ignored. I think the agency is really behind space technology, and think we have made significant progress. It is not as muc progress, unfortunately, as many of us would like to see, but ther is progress nevertheless.

Mrs. Morella. I don't mean to harangue the issue, but it jus seems to me when you talk about the progress and then Chairma Nelson's comments that we are putting money, it seems, int things and not in the people to run them. I become more convince with each hour of every day when I go from NIST to NASA t NIH, go through the whole gamut, that I think it is misplaced priorities, from what I hear.

I wonder if you wanted to comment on what is being done abou it. I understand NASA is looking into a program that gives mor flexibility in terms of pay and personnel that NIST is involved i or has been involved in for a couple of years.

Do you know anything about that, Dr. Rosen? Also, another par of that question, when you say people are leaving or you ar having difficulties and you say pay is one part of it, well, whe they leave, they must say why they are leaving or why they ar not coming in. Is pay 90 percent of it? Is it lack of recognition? You say something about lack of excitement. It should be excitement what is being done here. Is it lack of recognition?

And has the public service group, you know, headed by Paul Volcker, ever been involved with what you are doing? Maybe you can answer.

Dr. Rosen. There are many parts to the question.

Mrs. Morella. Yes.

Dr. Rosen. Let me take the last first with respect to the people who are leaving.

I think that the major reason that we have difficulties has to do with pay. The excitement of the jobs in NASA are legendary and in fact are true. In my experience, I came—you know, I am one of the very few people in OAST who came from industry and I found that the work there is tremendously stimulating. I think most people are very satisfied with the quality of the job.

The difficulty, unfortunately, is that when you spend 8 or 9 or 10 to 12 hours here, then you go home. Then you deal with the real world, and the real world has to do with the fact that there is a factor of two or more in the pay. And it is very difficult to say, well, for my entire career I am going to give up that kind of pay.

There is a very, very specific problem that we have not talked about either in the press, as far as I can tell, or in the testimony before, but there's a very, very difficult problem attracting people into the agency.

Let me be very specific on that. In OAST in the last five years we have been able to attract one person, and that is me, and there is a special reason for that. Since 1982 we have managed to attract three people. One of those was somebody who was in and out of the Government, so that really doesn't count.

I personally have made several attempts to bring people—we have had some openings—I have made several attempts to bring people from industry into OAST in certain jobs that they would be perfectly qualified for. And in fact, they would be a tremendous addition to the Government.

In the first case, I spent a lot of time trying to find the right person. We searched. We found somebody. I spent a lot of time on the telephone with this person. We decided that the next step was to bring him here to Washington and have a face-to-face conversation, show him around.

I made one closing comment at the end of the conversation after maybe spending five or six hours on the phone with him. I said, by the way, you do know that the Government doesn't pay very well.

He said, well, yeah, I have heard that, but how bad is it? I told him, and the conversation was over in a minute. He just simply said, I can't do that. And I said, well, there is really not very much that we can do. There is not any flexibility in this. He said, but I just can't do that.

You know, he thanked me and I thanked him, and that was that.

Another attempt I made to bring somebody in, another very qualified person, I got—they didn't wait for 4 or 5 hours. They got to the pay issue right away, and his remark to me was the job sounds great, but he said it would cost him $40,000-$50,000 a year. He said I can't afford to take a $40,000-$50,000 pay cut.

So when we talk about the shortage of people in government or lack of national stability, you know, you cannot separate the fact that the pay outside is a lot different than the pay in government, and we have some problems attracting people.

Mrs. **Morella**. They are not interested in SES because there is the cap? Basically, is that why?

Dr. **Rosen**. They are not interested in SES because they don't want to take the pay cut to come to the government.

Mrs. **Morella**. To even come into government?

Dr. **Rosen**. That is right.

Mrs. **Morella**. At that particular level.

NIST has a program that does allow some flexibility.

Dr. **Rosen**. Now, I think what you are talking about here is an alternate personnel system.

Mrs. **Morella**. Yes.

Dr. **Rosen**. That would be a very effective system, not for the top men but to bring people in at the beginning ranges.

The alternate personnel system would give us a lot more flexibility in the GS levels, and we are very interested in pursuing that.

I think there will be a lot—Noel Hinners, who is going to testify before you in a little while, I think, could get into more of the detail.

My understanding of the system is that it would allow us to have flexibility in the salary ranges at which we bring people into the agency.

But once again that is in the GS levels and at the lower level. It would enable us to attract people from college who were outstanding students and have tremendous potential and not be forced to putting them into a very narrow band. If they had that potential, we could bring them in at a higher band, providing the whole thing would be pay neutral, and that is being designed to do that.

Ms. **Morella**. Yes.

Have you heard anything about the Volker Commission?

Dr. **Rosen**. No, I am afraid I haven't.

Ms. **Morella**. Okay. Maybe someone else has.

I thank you. I don't want to usurp any more time.

Mr. **Nelson**. Well, that is certainly an important part, but it doesn't underscore—I mean, it doesn't tell the whole story about this office.

Now, why—first of all, is this true or not true, that you requested of OMB $437 million and they cut almost $100 million and allowed you to request of the Congress $338 million?

Is that correct?

Dr. **Rosen**. Those are true statements, Mr. Chairman.

Mr. **Nelson**. Okay.

Dr. **Rosen**. We did ask for that, and between the beginning of the process and the end of the process it was $100 million less.

Mr. **Nelson**. Why?

Dr. **Rosen**. I think that some of that cut was—well, basically, Mr. Chairman, the reason for the cut was the fact that the overall agency budget can be just so large, and we got down to the discussions of priority within the agency.

Mr. **Nelson**. So it gets back to this is the easiest place to cut?

Dr. **Rosen**. This is a place to cut.

Mr. **Nelson**. Well, I don't expect you to answer any more than that, and I certainly understand and I respect it.

These kind of things have been done by the NRC, Space Technology to Meet Future Needs. They say what we ought to be doing, and this is not what we are doing, and I can tell you this committee is going to change it. It is going to change it this year.

Let's see, Mr. Perkins and then Mr. Stallings.

Mr. **Perkins**. At this juncture, Mr. Chairman, I had just as soon—I would kind of like to—I have not read his report. I would kind of like to hear his presentation or see what is in his report prior to questioning.

Mr. **Nelson**. Mr. Stallings.

Mr. **Stallings**. Well, there is a number of different questions raised at this point.

One that I find interesting and a little disturbing, NASA has had more than a year to find a permanent replacement to fill the current vacant in the Associate Administrator position that heads your office.

Why is this position still unfilled? Is it a matter of dollars?

Dr. **Rosen**. I don't believe that is totally it, Mr. Stallings, but I am afraid I really can't answer that. I am not usually the person who hires my bosses, and I think the Administrator would be the right person to answer that.

I understand in the recent months the Administrator has been looking for a permanent replacement. Dr. Ballhaus was there for a year. He filled that position ably, and he knew that was going to be for a year, and in the recent months the Administrator has been looking for a permanent replacement.

But I don't know where that stands.

Mr. **Stallings**. Now, did he come on the basis that he would take the job only for one year and then he would move?

Dr. **Rosen**. That is correct.

Mr. **Stallings**. I guess that is my question. If he came with that condition, why do we wait till the guy goes before we start looking again?

Dr. **Rosen**. Mr. Stallings, I am really not the right person to ask.

Mr. **Stallings**. I know, but this is very frustrating.

Mr. **Nelson**. I will tell you what, Dr. Fletcher is coming back. When is he going to be here?

23rd? Why don't you proffer that question to him when he is here?

That is an excellent question, Mr. Stallings. I mean, why can't we plan ahead? Everybody knew that Dr. Ballhaus, who is an eminently respected scholar and administrator, was going to be here for a year, and he left a few months ago. so why?

That is a good question. Let's just get that directly to the source.

Mr. **Stallings**. I have no other questions, Mr. Chairman.

Mr. **Nelson**. Would you like to flesh in other things that we have not touched upon?

Dr. **Rosen**. I think what I would like to do, Mr. Chairman, is just talk a little bit about our major programs, CSTI and Pathfinder and In-Space Technology Experiments Program that we are beginning this year.

CSTI was the first program that we put forward as a focus program, and it was the first one in our series now to revitalize the space technology budget.

I think that program is going very well. We have made some significant progress in some areas, and we are very pleased with the kinds of technologies that we are getting out that.

The budget request we have in CSTI is $145 million this year. It is up $23 million from last year, and I would like to just make a comment that I urge the Committee for full funding of that particular budget.

CSTI is not a base research program. It is a research program that has large-scale hardware associated with it. It has milestones and deliverables. It is the program that we said we would—in which we said we would provide deliverable technology to the agency.

We have, unfortunately, had some budget cuts in the past, and we think it is essential that we don't have any more budget cuts. Otherwise, that program is going to start slipping back and start looking like a base technology program.

The idea is that we cannot buy, simply can't buy CSTI technology by the yard. We need to have it as a focus program with a budget distribution associated with it, and I think we can continue to make some very good progress as long as we have the budget

Pathfinder is probably the most exciting program, or one at least, that the agency has got, and we are disappointed, as I said earlier and as I know you are, with the budget level.

But let me say in defense of the program, it is a startup program It is in a startup mode, and we are able this year with the kind of funding we have for '88 and '89 we think to make a very reasonable start on the program. Long term, we could not provide the technology for the country at that level, not the kind of Pathfinder technology that we have talked about, but as a startup program we think it is a very viable program, and we think sometime in the future we will have to grow it. But I think today what we have got beginning is a good program.

With respect to the In-Space Experiments Program, that is something that we felt for some time that we needed to have forward, needed to put forward, so that we can have a balanced program, balanced between the ground-based research that we do and space-based research that is needed to complement what we do on the ground.

We are very excited about getting that in the budget, and we think that that kind of program will make our overall space technology effort much more balanced and produce much more useful products in the long term.

I would like to characterize the budget. Although the growth in it is not as great as we would like, it is a growth budget.

As you said earlier, there have been some very, very lean years. This year is a growth. There have been years where that didn't happen, and I think to just short-change the growth is not entirely correct. There is growth. We would all like to see more, and I think the difference between today and tomorrow is the technology that we have available to us. I believe with this kind of budget we will increase our technology progress.

That concludes what I have to say, Mr. Chairman.

[The prepared statement of Dr. Rosen follows:]

STATEMENT

OF

Dr. Robert Rosen
Deputy Associate Administrator for
Aeronautics and Space Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Space Science and Applications
Committee on Science, Space and Technology
House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittee:

I am indeed pleased to have this opportunity to present to you NASA's FY 1990 Space Research and Technology (R&T) budget request. As you know, the basic goal of NASA's Space R&T program is to enable and enhance future potential civil space missions by providing a solid base of technical capabilities and talent. With your support, we will be able to continue our progress toward that goal, expanding the frontiers of technology to enrich our Nation and capture the benefits of space for future generations.

Advanced technology has played a major role in the past successes of the civil space program, and is the foundation for success in undertaking potential future missions to serve the Nation's goals in space. Adequate investment in such technology lowers the cost, the risk, and the development lead time associated with our activities in space. New technology is the key to the future; without it, we are locked in the present.

The importance of space technology to the Nation, however, goes far beyond NASA's next program or mission. The development of these advanced technologies enhances the economic competitiveness of our aerospace and related industries, contributes to the national security, and serves as a stimulus to the education of new generations of scientists and engineers.

Unfortunately, over the years the Nation's space technology capabilities have not kept pace with the Nation's space technology needs. After peaking in the early 1960's, NASA's investment in Space R&T declined - in terms of constant purchasing power - to less than 20 percent of what it had been at the height of the Apollo era. As a result, many programs became limited by a lack of technology options, particularly with respect to validated, or user-ready, advanced technologies.

At the same time, many other most capable and farsighted countries were laying plans for aggressively targeting aerospace and related high-technology industries as strategic thrusts for the twenty-first century. Those technology development efforts have already begun to pay off in the form of significantly enhanced space capabilities - for France in expendable launch vehicles and earth observing systems, for Canada in space-qualified robotics, and for the Soviet Union in planetary exploration, heavy-lift launch vehicles, and an evolving, permanently innabited space station. As summarized by the National Academy of Sciences, the result of this imbalance in investment was that "the United States is losing its competitive lead in space, and new technology is unavailable to offer the nation a selection of future options in space."

Within the past few years, however, there has been widespread recognition and support - in Congress, in the Administration, and elsewhere - of the need to revitalize our national space technology capabilities. In response to this need to invest in our Nation's future in space, and in response to the broader need to strengthen the capabilities and talents for supporting all national space sectors, civil, national security and commercial, NASA developed a balanced strategy for the conduct of its space R&T program; namely:

- Maintain a strong and innovative R&T Base program: research into basic long-term, high-payoff space technologies
- Revitalize the Nation's technology for applications in Earth orbit through the Civil Space Technology Initiative
- Initiate the Pathfinder program to develop the enabling technologies for the potential, future exploration, both human and robotic, of the solar system
- Extend the Nation's space technology development activities to experiments in space
- Broaden the participation of the nation's universities in the conduct of Space R&T
- Focus ongoing R&T base activities, as needed, to enable the initiation of new technology programs to serve appropriate national needs.

With the support of the Administration and this Committee, NASA has begun to implement this strategy. In FY 1988, the funding of the Civil Space Technology Initiative (CSTI) signaled the beginning of the revitalization of the Nation's space technology capabilities. And, in FY 1989, we began to lay the foundation for future expansion of human presence and activity beyond Earth orbit into the solar system - with the initiation of the Pathfinder program.

NASA's FY 1990 Space R&T budget request represents a balanced and responsible continuation of that overall strategy. Of the total request of $338.1 million, $130.1 million is for basic disciplinary research in aerothermodynamics, materials and structures, power and propulsion, and other key space technology fields; included in that total is support for the recently-initiated University Space Engineering Research Center program. In addition, $144.5 million is requested for CSTI - to continue the long-needed, systematic revitalization of our Nation's space technology capabilities - and $47.3 million for the Pathfinder program - to investigate the long lead-time technologies that will be required for all potential future exploration missions. Finally, we are requesting $16.2 million to initiate an In-Space Experiments Technology Program to begin working toward the appropriate balance between ground-based and in-space research and technology development.

To repeat, our strategy is balanced and responsive to a range of important national priorities. Our FY 1990 budget request continues the implementation of this strategy. Although it is a growth budget, it represents the investment necessary to maintain movement toward our future space goals.

Let me highlight some of the programs associated with this budget request:

Civil Space Technology Initiative

The Civil Space Technology Initiative (CSTI) was the first of NASA's new focused technology programs (in contrast to the fundamental disciplinary research conducted as part of ongoing R&T base activities). CSTI was designed specifically to: (1) fill the gaps in the agency's basic technical capabilities that had resulted from too many years of reliance on Apollo-era technologies; and (2) advance critical technologies to the point of user-readiness for safe incorporation into relatively near-term, high priority NASA missions.

The CSTI program has already begun to produce significant accomplishments in key focused technologies, including automation and robotics, space power, and information technology. These and other technologies will be utilized in the systems of the 1990's to provide cost-effective and reliable access to, operations in, and science missions from Earth orbit.

As a focused program, CSTI is different from the traditional Space R&T program. As mentioned above, CSTI was intended to take technologies beyond the basic research stage - to demonstrate the benefits and reduce the risks associated with specific advanced technologies. Also, the elements of CSTI were designed to result in deliverables, ranging from ground-demonstrated propulsion and structures hardware to data acquisition and processing techniques.

CSTI is characterized by large-scale hardware and by commitments, milestones, and delivery dates. Certain levels of investment are therefore necessary for the successful realization of the CSTI effort. The FY 1990 budget request of $144.5 million represents the amount of investment necessary to maintain the character of the CSTI effort. The implications of a smaller investment are clear from last year's experience: significant and costly replanning efforts; the "stretchout", reduction, and rescoping of contracts; slippages in technology milestones of up to 18 months; and, equally important, a real reduction in the enthusiasm and excitement that has been clearly evident in the scientists and engineers engaged in this critical work.

Pathfinder

Pathfinder, initiated in FY 1989, consists of a group of research efforts addressing surface exploration, in-space operations, humans in space, and space transfer. The technologies developed in these areas will be the key to making decisions on all potential future solar system exploration.

Pathfinder is, at this point, in a startup phase. Activities have been started across a range of important technologies, with multi-Center teams being put into place and some procurements initiated. Many elements have been reduced in scope, however, and others - such as research in photonics, cargo vehicle propulsion, and resource processing pilot plants - have been deferred as a result of reduced funding.

Pathfinder remains an essential part of the National Space Policy and of the NASA Program, but we reluctantly limited its budget growth for FY 1990. This request reflects the need to balance a range of national needs in a tight fiscal environment. Although Pathfinder has been slowed from our initial expectations, a viable startup program can be maintained through FY 1990.

In-Space Experiments Technology Program

The effort to revitalize our Nation's space technology (as begun by CSTI) has been focused on ground-based research and development. Our space missions also require technology for operations in space. In many instances, it is essential that the development of that technology be conducted in the actual space environment. To round out the strategy for the revitalization of our technical capability, we need to establish a proper balance between ground-based and in-space research.

The In-Space Experiments Technology program will develop flight experiments to test highly innovative technologies, identified through ground-based research, that require research, testing and validation in the space environment in order to understand basic phenomena, reduce risk to potential users, and increase the rate of technology transfer to future space missions. Among the areas requiring in-space experimentation are fluid behavior in microgravity environments (critical to the design of advanced thermal management, power, propulsion, and life support systems); the use of robotics in space construction, servicing, and other in-space operations; and environmental effects on materials from long-term exposure to the space environment. One example of the benefits of this work can readily be seen from the proposed arcjet experiment, which will lead to the development of an advanced rocket motor for station keeping that will enable communications satellites to remain on orbit for longer periods of time, greatly increasing the useful life of the spacecraft.

In addition, in response to recommendations from NASA's advisory groups that we provide opportunities for the private sector and university space engineering communities to conduct in-space experiments, we have made an industry/university outreach program an integral part of the In-Space Experiments effort. To date, we have selected five industry and university proposals for development and flight validation. Typical of these is the tank pressure control experiment which will validate the mixing and stratification characteristics of fluids in a zero-gravity environment. Data collected during the experiment will contribute to reducing the cost and complexity of fluid tanks in future spacecraft.

The FY 1990 budget request of $16.2 million will fund development and flight validation activities for both selected in-house and industry and university experiments. With this augmentation, new in-space experiment development activities will be funded under the In-Space Experiments program. Work to define future experiments will be funded, as is appropriate, in the Base itself. (For example, another thirty-six Outreach proposals for future in-space experiments have been selected for further definition as part of an ongoing R&T Base activity.) Finally, although these experiments are designed to be conducted primarily onboard the Shuttle and ELV's, many of them will serve as precursors to experiments that will use Space Station Freedom's unique facilities as they become available later in the next decade.

Again, the decision to request funding for this program is not one that was made lightly. It is important to restate, however, that the overall strategy of the Space R&T program is one that calls for a vigorous revitalization of the Nation's space technology. The successful implementation of that strategy requires that NASA pursue a balanced program, addressing both ground-based and in-space R&T.

National Capability

The Nation's future in space, of course, depends on more than just the development and testing of technologies themselves. Our future depends upon the continued availability of qualified scientists, engineers, and managers who are able to conduct and administer programs to expand our national competence in space technology. Broadening NASA's partnership with universities continues to be an integral part of the Space R&T program. For example, the In-Space Experiments Technology program will provide opportunities for developing technical strengths in the engineering disciplines within NASA, industry, and academia alike.

The recently-initiated University Space Engineering Research Center (USERC) program is another key element in this NASA/university partnership. These Centers, important catalysts that bring together people, knowledge, and methodologies, conduct focused research in one or more of the traditional space engineering disciplines, and in cross-discipline combinations, to develop advanced techniques, tools and technologies for future space systems. NASA monitoring teams for each university Center ensure the timely flow of information and technology between the Centers and NASA programs and foster collaborative arrangements between Centers. The USERC program stimulates engineering curricula and increases the availability of qualified space engineers by making a long-term commitment to universities.

A key aspect of this program is the independence with which each Center will be operating. In contrast to some other types of university involvement where the academic institution primarily conducts research in a very narrow area, under the USERC program each Center will be able to identify and pursue its own avenues of inquiry within a broad charter. This freedom and flexibility will encourage innovation on the part of students and faculty alike, and result in valuable new contributions to the Nation's civil space technology effort.

The first USERC solicitation occurred in August 1987. Over one hundred institutions responded to that first solicitation with outstanding proposals - and with extreme enthusiasm. Nine were selected as follows:

- University of Idaho: VLSI Hardware Acceleration Center for Space Research
- University of Arizona: Center for the Utilization of Local Planetary Resources
- Rensselaer Polytechnic Institute: Intelligent Robotic Systems for Space Exploration

- North Carolina State University and North Carolina A&T University: Mars Mission Research Center
- University of Cincinnati: Health Monitoring Technology Center for Space Propulsion Systems
- University of Michigan: Center for Near-Millimeter Wave Communication and Sensing Technology
- Massachusetts Institute of Technology: Controlled Structures Technology
- University of Colorado: Center for Space Construction
- Pennsylvania State University: Center for Space Propulsion Engineering

Educators continue to praise the USERC program. One called it "one of the most creative and innovative university programs"; another said that it was "one of the most significant developments in the history of the university." The first comprehensive review of this program was held this past January and confirmed the value of the program to both NASA and the academic community.

NASA Capability

A successful NASA program depends critically on the capability of its staff. You have heard Dr. Fletcher, and you will hear others, testify on the need for maintaining the continued health and strength of NASA's institution, particularly its people and its unique research facilities. Perhaps nowhere is this need more vitally felt than with regard to the Space R&T program. As we work to revitalize the Nation's space technology, we must remember that people are the core of our capability. The increased emphasis on technology development, as represented by CSTI and Pathfinder, needs to be matched with a corresponding long-term investment in human resources. To do otherwise would be to provide only half of a solution.

Similarly, we must continue to make available to these researchers - and to other appropriate users - the state-of-the-art facilities required to support advances in critical space technologies. Many of these facilities are unique national resources; all of these facilities contribute to the successful attainment of the Nation's goals in space.

In short, program strength comes from, and requires, outstanding people and facilities as well as adequate program funds. We request that you support the revitalization and invigoration of NASA's workforce and facilities as represented in the agency's Research and Program Management (R&PM) and Construction of Facilities (CofF) budget requests. Such support is central to the continued success of the Nation's civil Space R&T program.

Space Technology: An Investment in the Future

We have made great strides, but we cannot afford to lose any momentum if we as a nation hope to maintain our future in space. The FY 1990 Space R&T budget is a tight budget that represents a balanced program that will continue revitalizing our Nation's space technology capabilities. It is important to keep in mind that these programs, the R&T Base, CSTI, Pathfinder and the In-Space Experiments Initiative, are important not just to NASA but to the Nation's ambitions in space as well.

Dr. Fletcher has cautioned that "long-term investments are always an easier political target than are deliveries of current services." As in most cases, the easy path is not the right path. Postponing advanced research has an effect just as real, an impact at least as great, as missing a flight opportunity or any other near-term milestone. The only difference is that the impact may not be apparent for years to come - and by then it is too late to correct.

With this critical investment in technology, as reflected in our budget request, we can look forward to a future of exciting possibilities in space. And, American technology will be pushed forward across a wide spectrum, reminiscent of the impact of the Apollo program in the mid-1960's. We are asking you today to support our effort, to continue this critical investment in our technology foundation to keep the Nation's civil space program on track, preserve our future options in space, and expand the frontiers of the future for the benefit of all Americans.

SPACE R&T BUDGET

OAST

	FY 1989	FY 1990
SPACE R&T	295.9	338.1
R&T BASE	134.1	130.1
CSTI PROGRAM	121.8	144.5
AUTOMATION AND ROBOTICS	25.9	25.9
PROPULSION	36.1	37.4
VEHICLE	13.3	36.0
INFORMATION TECHNOLOGY	15.9	15.6
LARGE STRUCTURES AND CONTROL	19.5	18.9
POWER	11.1	10.7
PATHFINDER PROGRAM	40.0	47.3
SURFACE EXPLORATION	8.5	9.3
IN-SPACE OPERATIONS	15.0	15.6
HUMANS-IN-SPACE	6.0	6.3
SPACE TRANSFER	5.5	6.1
MISSION STUDIES	5.0	10.0
IN-SPACE EXPERIMENTS TECHNOLOGY PROGRAM	----	16.2

KAD0020

Mr. **Nelson**. Will you be happy if we give you more money?

Dr. **Rosen**. I think that is an agency decision.

Mr. **Nelson**. Well, let the record show that he is smiling ear to ear. [Laughter.]

Dr. **Rosen**. I couldn't control that.

Mr. **Nelson**. Members?

Mr. **Perkins**. Mr. Chairman, I would like to comment somewhat, and I have talked about this in the past to some extent, and frankly in this NRC report I was just looking at I have seen the same thing that I saw when I read the report by the National Commission on Space a number of years ago, where one of the recommendation was that we have an increase in the funding level of research and development to some rather constant rate similar to what we had in the '60s, so that we in fact are in a position to do something about the future.

All the great investments that we have gotten and are using and utilizing as part of our society, as part of this that are offshoots of the space program, came as a direct result of the research and development and effort that followed a national commitment that was made in the '50s and into the '60s.

It is dramatically illustrated. Since 1972 we have seen the funding levels go down dramatically for R&D. At the same time we have seen our lead in so many different areas in space slip away at the same time.

It is difficult to ask a question about this because you are not OMB. You understand, I am sure, the problems that are associated here, and certainly I don't really have a question per se, just this frustration level that it seems that year in, year out, we have people coming in front of this Committee, and we talk about the need to see increased research and development funding. We have some increases in research and development funding, which I suppose is better than we have had in the past.

But still the prioritization process doesn't seem to be such that research and development in the basic systems is being given what I would consider a necessary funding level if we are going to be anything other than second-rate in space into the future.

And when we see some of the reports; for example, the National Research Council is saying for the last 15 years NASA's investment in basic research and technology development has been lower than the sustaining level required by most industries.

Well, why, if NASA is supposed to be in fact a government agency that is designed to really get into research—is my understanding of one of NASA's basic functions—why is basic industry out there that is supposed to be just trying to make money, in effect, having a better R&D program than NASA has?

You understand what I am asking. Pick your spot. I don't know where to start or what to say. It is just a very frustrating type situation.

Dr. **Rosen**. Well, let me say, Mr. Perkins, that the agency isn't pleased with the level of technology funding. We would like to have a higher level of funding in space technology. Let me make that one comment.

Dr. Fletcher, when he was faced with the overall budget limitations, made some very hard choices, and unfortunately part of what he deemed proper was the growth in Pathfinder experience and that could be only $47 million.

But to counter what you say a little bit, there is space technology in this R&D and an awful lot of what we do in the R&D is technology. The Space Station, an awful lot of the Space Station work is good technology, and so to link us—to say that this agency is not putting any money into R&D or putting a very small fraction of its budget into R&D is not entirely correct.

Mr. PERKINS. I don't want to dispute your statement, but I have had people that are directly associated with the Space Station, without mentioning any names, indicate to me that the technology was presently available for what we were doing with Space Station. In fact, it was something that we were quite comfortable with and there was very little in terms of new development that was going into the Space Station at this juncture.

So really I see the Space Station more as infrastructure, an absolutely vital and critical infrastructure, understand, but at the same time this is not what we did to get to the moon.

Dr. ROSEN. That is right.

Mr. PERKINS. In essence.

Well, again I realize this is not your decision, and so, Mr. Chairman, I really have no question.

Mr. NELSON. Mr. Mineta.

Mr. MINETA. Thank you very much, Mr. Chairman. I really don't have too many questions, although I would like to just make one observation, and that is that we have had an Acting Administrator for the Office of Aeronautics and Space Technology, as you very well know, Mr. Chairman, in Dr. Ballhaus, and unfortunately, of course, he is not here today, but I just wanted to say that in his absence that I would like to offer my own appreciation and hopefully on your behalf as well, Mr. Chairman, this subcommittee's appreciation to him for the job that he did as the Acting Associate Administrator for OAST.

He is now back at Ames as the Director there, and I just—the thing that I guess is sort of troubling is that the history of the Associate Administrator of OAST—we have had so many in the last several years—I just wondered, Dr. Rosen, why is it that we have this high turnover there?

Maybe I shouldn't be asking you this, I should be asking someone else higher up.

Mr. NELSON. The smiles in the room is that that question has already been asked.

Mr. MINETA. Oh, it has been? I am sorry.

But it just bothers me because when you talk about long range planning, you know, how do you do long range planning with a revolving door, not knowing whether the person there in the front office is going to be there next week or not?

Dr. ROSEN. Well, I agree, that is a critical problem that we have, Mr. Mineta. I don't have a crystal ball answer.

I know it is a concern of Dr. Fletcher. He and I have discussed that a little while ago, and he would like to be able to find somebody who would stay and OAST would like to find somebody who would stay as well.

Mr. MINETA. Well, I just feel that Dr. Ballhaus took on a very difficult job at a difficult time. He did the job admirably and did a great deal of service to NASA and to his country.

Dr. Rosen, I would like to ask about the alternate personnel system that he wanted to institute.

Has that been addressed also, Mr. Chairman?

Mr. NELSON. I am sorry, I didn't——

Mr. MINETA. The alternate personnel system that Dr. Ballhaus was attempting to put into place, has that also been a subject of this discussion here at all?

Mr. NELSON. No, please.

Mr. MINETA. I was wondering, is there any chance that NASA will be conducting any experimentation along this line?

Dr. ROSEN. Yes, sir.

We have received approval from OMB to proceed to put together such a plan, and in fact there is a conference going on right now in Monterey with people from the OAST Center as well as the Flight Center and people from Headquarters to look at what an appropriate plan would be, not for one center but for the agency overall, and I believe the current plan right now is to proceed with one center.

However, that really does need to be with the kind of program that would be appropriate for the entire agency. So we are proceeding.

At such time as we come up with the appropriate alternate personnel system for us, we will then go back to OMB and OPM and discuss it with them.

Mr. MINETA. Has the center been designated yet?

Dr. ROSEN. It would be Ames.

Mr. MINETA. It will be Ames?

Dr. ROSEN. The Ames Research Center, that is right.

Mr. MINETA. Let me ask, in the Pathfinder Program, as I understand it, this has only been funded at 40 percent of the requested amount, and in order to get NASA geared up for choosing between the missions as far as the next major near earth orbit is concerned, what kind of funding level do you feel is going to be required for that?

Dr. ROSEN. Let's see, for me to understand your question, do you mean the long term level kind of funding which will provide the technologies that we need for Pathfinder?

Mr. MINETA. As I understand it, in terms of the beyond near earth orbit, and that is the next major goal, the fact that you have only got 40 percent of your requested amount, what will be the impact of that in terms of your long term technology planning and, since the next step is—I suppose Space Station is one of the elements, and one of the things I would like to get at specifically is SP-100, but I am just wondering in terms of the 40 percent funding level what happens to all of this.

Dr. ROSEN. Well, I think you asked a lot of questions. Let me go through that.

I think the funding level that we think we would need in order to provide the Pathfinder technologies and have them available for the agency and the country to use would be around $200 million per year, and that would take several years worth of work at that kind of level.

We think that what we have right now is the startup program that is on the way to that kind of funding level, and we think we are going to make some very significant progress getting ready to get to that level.

But I think what it will take in order to provide the technology is about the $200 million.

Mr. MINETA. Let me ask about—I thought it was 40 million for fiscal year '89 and that the fiscal year '90 had even been further scaled back.

Dr. ROSEN. No, sir, it is $47 million in 1990.

Mr. MINETA. 47?

Dr. ROSEN. 47. So there is an increase of $7 million.

Mr. MINETA. All right, and let me ask about within this Pathfinder the SP-100 program.

This is NASA, SDI——

Dr. ROSEN. DOE.

Mr. MINETA [continued]. DOE funding, and everyone has scaled back on the funding on this, as I recall, and I am just wondering where we are going to go with this.

What is the status of the SP-100 program within NASA?

Dr. ROSEN. Let me begin the answer to that question by telling you how important we feel the SP-100 program is to our future requirements.

We have looked at several applications of space nuclear power and find that in some cases space nuclear power would be enabling to the mission and in very many other cases it would be enhancing.

Such things as a moon base or a Martian base would be dramatic. A lunar base in the first case would probably only be enabling by a space nuclear reactor. A Martian base would be greatly enhanced, as would a planetary mission to the far planets.

For these reasons we think that it is essential that this agency develop the technology for a space nuclear reactor, and for that reason we have joined with SDI and DOE in that program.

Now, there have been some cutbacks in the funding, but the way the program stands right now is that we will have a key test, the key test in 1994, which is the nuclear reactor system, along with some of the complementary systems that will occur—tests will occur at Hanford, Washington, and we think that that 1994 test is the key to prove the feasibility of a space nuclear reactor, and we are looking forward to that test.

Mr. MINETA. Now, is that 1994 a date that has been pushed back because of——

Dr. ROSEN. Yes, sir.

Mr. MINETA. I mean, as I recall the funding levels, it is just about half. NASA has cut back to what they had contemplated. I think it is, what, $10 to $12 million when it should have been up around the $25 to $30 million level.

Dr. ROSEN. That is right.

Mr. MINETA. I mean, SDI was up around $50 to $60 million and they are down around to $30 million, and DOE has also cut back to about the same level as NASA.

Dr. **Rosen**. Not quite that bad, Mr. Mineta, but there have been serious cutbacks, and the result of that is that we in fact have taken parts of the program and had to eliminate them and there is other parts of the program we have deferred.

We have some funding going on in our CSTI program high capacity power, and that work is basically work that we were doing in long lead technologies to complement the SP-100 program.

SP–100, faced with the budget cuts and the fact that they knew we were doing those technologies, that has essentially taken their work and eliminated some of those works, and now CSTI is—the effort in CSTI will provide those long term technologies and be essentially part of the program.

But what we have had to do is we have to reprogram in order to make—get to the key test within the kind of budget level that we have got, and I think we have been successful in doing that.

Mr. **Mineta**. Mr. Chairman, it just seems to me like the other day when we were having the hearings relative to life science versus materials science and whether there is going to be the experimentation being done in the lab module or is it going to be in a node by itself and that is all driven by power requirements.

I mean, here is something that we really need and yet we are cutting back on it, and we are just short-changing ourselves in the whole picture all the way down the line, and it just seems to me that it just is really discouraging from my perspective. For you folks there that have to work on it on a day-to-day basis, it has got to be really discouraging.

But to me we are being very, very short-sighted in terms of what we are doing with the funding level on some of these programs.

Mr. **Nelson**. It is discouraging to all of us, Mr. Mineta.

And picking up on your first question, I think a legitimate follow-up to that after you pointed out the turnover of 21 Associate Administrators in 20 years, and you have to ask yourself is it because of that lack of stability in the Associate Administrator that there is less political clout in order to get their bigger share of the budget.

I am not even going to ask that question to you, Dr. Rosen, because I know you can't answer that, and I appreciate that fact.

But let the question hang out there as a very legitimate inquiry, which we will proffer to Dr. Fletcher when he is going to be here.

Thank you.

Mr. **Mineta**. Thank you very much, Mr. Chairman.

Thank you very much, Dr. Rosen, for your work there as the Deputy. I know you have done a great job, and so has your whole crew.

Mr. **Nelson**. Mrs. Morella.

Mrs. **Morella**. Thank you.

Dr. Rosen, in looking over your prepared testimony here, you are very excited about the University Space Engineering Research Center and the fact that you have established these centers at a number of universities that are listed and how it is going to help with the availability of qualified space engineers by making a long-term commitment to universities and that it has been praised by educators and others and that the first comprehensive review took place in January.

Can you tell us briefly why it is so spectacular, what guarantee you have that you are going to have these space engineers that we need and whether the program is going to be expanded?

Dr. ROSEN. Sure. Part of the reason has to do with, I think, the students' love for space. We are told constantly by university administrators and faculty members as well that all you have to do is talk about space to the graduate students, to the undergraduates and they really get excited. They are able to attract the brightest and the best graduate students to this program.

They are very, very excited about how the people seem to flock around, and you know one very important feature of the strength of NASA is their people, and what this will help us do is attract and keep in graduate schools some of those engineers that might have gone away, but they will stay in graduate schools and they will stay to work on space-related activities.

Obviously, the program is brand new. We don't have any concrete results from it yet, but we see the enthusiasm in the schools.

We see the enthusiasm in the states as well as well as a tremendously high leveraged program. Most states are interested in doing something to support their universities and to support this program, and so we think that we are going to get more out of it by far than what we have put in. We will get more out of it in the financial aspect as well as in enthusiasm.

Mrs. MORELLA. They may end up in the private sector.

Is there any chance that this program as it develops to get these people to make a commitment in return for the kind of experience that they are having working with NASA as well as with other specialists?

Dr. ROSEN. Mrs. Morella, one of the goals of the program is to make some of these centers self-sufficient by having an interaction between the space engineering university research centers and industry itself. What we would like to do is get to the point where these research centers will work with industry and support industry in their activities and eventually be able to step back and then go on to other research centers.

Mrs. MORELLA. Then how does NASA benefit from it?

Dr. ROSEN. Well, the benefits are dramatic. We select major topics that these research centers work on, and so what goes on in a research center—we are not asking for specific fundamental research in one particular area. Basically, we are looking for interdisciplinary kind of research.

So, for instance, one of our research centers is working on methods to get to Mars. Another one is working on overall propulsion systems. What we will get out of that is some of these innovative concepts that are best developed in a university by people doing university kinds of things and being able to think as broadly as they can.

Mrs. MORELLA. They are not reinventing something that has already been done?

Dr. ROSEN. They wouldn't be reinventing something.

Mrs. MORELLA. This is going to be innovative?

Dr. ROSEN. And they wouldn't be constrained by the fact that they know their boss somewhere is interested in a particular topic and they are going to please him——

Mrs. **Morella**. And it gets reported back to NASA?

Dr. **Rosen**. That is right.

Mrs. **Morella**. How come you don't have University of Maryland, so close to Goddard?

Dr. **Rosen**. We missed that one, I am afraid.

Mrs. **Morella**. No. Were they one of the ones that applied?

I don't know. I am half kidding. But you said something like 100 universities applied?

Dr. **Rosen**. Had over 100, that is right. That is correct. I don't know for a fact about Maryland. We can furnish that information.

[The information follows:]

The University of Maryland was one of 115 proposals that NASA received in response to the first solicitation for the University Space Engineering Research Centers program. Of these, nine Centers were selected in April 1988. Attached is a listing of the University proposals that were submitted and the nine Centers that were selected.

UNIVERSITY SPACE ENGINEERING RESEARCH PROGRAM

OAST

NINE CENTERS SELECTED FOR FY 1988

UNIVERSITY OF ARIZONA	CENTER FOR UTILIZATION OF LOCAL PLANETARY RESOURCES
UNIVERSITY OF CINCINNATI	HEALTH MONITORING TECHNOLOGY CENTER FOR SPACE PROPULSION SYSTEMS
UNIVERSITY OF COLORADO, BOULDER	CENTER FOR SPACE CONSTRUCTION
UNIVERSITY OF IDAHO	VERY LARGE SCALE INTEGRATED HARDWARE ACCELERATION CENTER FOR SPACE RESEARCH
MASSACHUSETTS INSTITUTE OF TECHNOLOGY	CENTER FOR SPACE ENGINEERING RESEARCH FOCUSED ON CONTROLLED STRUCTURES TECHNOLOGY
UNIVERSITY OF MICHIGAN	CENTER FOR NEAR-MILLIMETER WAVE COMMUNICATION
NORTH CAROLINA STATE AT RALEIGH AND NORTH CAROLINA AGRICULTURAL & TECHNICAL STATE UNIVERSITY	MARS MISSION RESEARCH CENTER
PENNSYLVANIA STATE UNIVERSITY	CENTER FOR SPACE PROPULSION ENGINEERING
RENSSELAER POLYTECHNIC INSTITUTE	INTELLIGENT ROBOTIC SYSTEMS FOR SPACE EXPLORATION

List of Proposals sorted by University

the University of Alabama	8018	Integrated Flexible Design, Evaluation, and Rapid Prototyping of Adv. Complex Space Syst.
the University of Alabama in Huntsville	8048	Propulsion Engineering Research Center
Arizona State University	8046	Center for Space Power Engineering
the University of Arizona	8072	Center for the Utilization of Local Planetary Resources
Auburn University	8034	Center for Thermal Management for Space Operations
Brown University	8050C	Center for Intelligent Space Systems (CISS)
the California Institute of Technology	8065	Center for Autonomous Systems and Computation
the California State Polytechnic University	8077	Center for Energy Management in Space System Design
the University of California at Berkeley	8098	Optimization-Based Integrated Design of Space Structures
the University of California at Berkeley	8100	Rarefied Gas Dynamics, Space Thermophysics, and Space Composite Materials Fabrication
the University of California at Los Angeles	8076	Space Structures and Materials Technology
the University of California at Los Angeles	8081C	Millimeter and Submillimeter Wave Technologies for Space Applications
the University of California at San Diego	8002	Intelligent Space Systems: A Program of Engineering Research and Advanced Education
Case Western Reserve University	8037	Material Processing and Construction Using Extraterrestrial Materials
the University of Central Florida	8083C	Spaceport Engineering Research Center
the University of Cincinnati	8042	A Health Monitoring Technology Center for Space Propulsion Systems
the Colorado School of Mines	8014	Center for Joining of Advanced Aerospace Materials
Colorado State University	8071	University Space Engineering Research Center for Lunar Bases

List of Proposals sorted by University

the University of Colorado at Boulder	8015	Center for Space Construction
Columbia University	8112	Mechanisms and Machinery Longevity in Space
the University of Connecticut	8114	Center for the Study of Durability of High-Performance Materials
Cornell University	8019	Space Engineering Research Center
Cornell University	8024	Center for High Precision Space Structures for Optical/Infrared Imaging Systems
Cornell University	8079	Millimeter Wave Transistors and Optoelectronic Devices
Cornell University	8105	Space Propulsion Center
Cornell University	8108	Space Microelectronics Center
Drexel University	8095	Center for Vehicle Automation for Planetary Landing and Exploration
Duke University	8066	Center for Research in Space Computing Engineering
the University of Florida	8087	Center for Intelligent Robots in Space
George Washington University	8115	Space Engineering Center in the Joint Institute for Advancement of Flight
the Georgia Institute of Technology	8005	Center for Tribology and Advanced Space Systems
the Georgia Institute of Technology	8029C	Center for Engineering Automation and Telerobotic Systems
the University of Hawaii	8036C	Pacific Center for Space Engineering
the University of Houston	8027	The Center for Gas-Liquid Flow Dynamics and Phase Change Heat Transfer
the University of Houston	8038	Space Superconductivity Engineering Research Center
the University of Houston	8045C	Center for Space Systems Software Engineering Research (CSSSER)
Howard University	8058	Space Engineering Research Center at Howard
the University of Idaho	8091	VLSI Hardware Acceleration Center for Space Research

List of Proposals sorted by University

Illinois State University	8099	Training in Development and Use of Computer-Aided Software Engineering
the University of Illinois at Chicago	8003	Reliability and Life-Time Expectancy of Advanced-Material Space Systems
the University of Illinois at Urbana-Champaign	8009	Center for Microgravity Simulation: Two Phase Flow & Heat Transfer
the University of Illinois at Urbana-Champaign	8055	Space Propulsion Engineering Research Center
the University of Illinois at Urbana-Champaign	8062	Center for Lasers & Sensors in Space
Iowa State University	8096C	Center for the Reliability of Materials, Manufacturing and Structures in Space
Kansas State University	8073	Space Engineering Research Center for Life Support Systems
the University of Kansas	8013	Space Transportation Applied Research Center (STAR CENTER)
the University of Kentucky	8092	Space Engineering Research Center in Robotics
Louisiana State University and A&M College	8056C	Center for the Development of a Permanently Manned Extra-Terrestrial Base
the University of Maryland	8007	Center for Space Vehicle Innovation and Technology
the Massachusetts Institute of Technology	8030	Controlled Structural Technology
the Massachusetts Institute of Technology	8031	Center for Space Robotics
Memphis State University	8086C	Center for Biomedical Space Engineering
Michigan State University	8026	Space Power Engineering Center
Michigan Technological University	8109	Processing of Nonterrestrial Materials
West Michigan RTC	8040C	Integrated Logistics Engineering Research Center for Space Facilities
the University of Michigan	8016	Center for Tele-Autonomous Systems Research
the University of Michigan	8053	Cryogenic Fluid Management Research Center
the University of Michigan	8069	University Space Engineering Research Center for Space Propulsion

List of Proposals sorted by University

the University of Michigan	8085	Center for Near-Millimeter Wave Communication and Sensing Technology
the University of Minnesota	8006	Center for Space Environmental Engineering
New Mexico State University	8078	Space Engineering Research Center in Tele-Engineering
the University of New Mexico	8044	Space Engineering Research Center for Power and Advanced Propulsion
the State University of New York at Buffalo	8060	Interdisciplinary Center for Advanced Space Structures
New York University	8021	A Center for Space Robotics and Autonomous Manufacturing
North Carolina State University at Raleigh	8061C	Mars Mission Research Center
the University of North Dakota	8032	Center for Lunar Materials Research
the University of Notre Dame	8004	Autonomous Planetary Exploration (APEX)
Ohio State University	8020	Center for Engineering Research in Space Structures and Control
Ohio State University	8089	Advanced Concepts in Space Propulsion and Power
Ohio State University	8090	Center for In-Space Construction, Maintenance and Repair
Oklahoma State University	8110C	Space Transportation Engineering Research Center
Old Dominion University	8106C	Center for Automatic Processing of Extraterrestrial Resources
Oregon State University	8094	A Space Power and Research Training Center
Pennsylvania State University	8025	NASA Center for Space Propulsion Engineering
Pennsylvania State University	8049	A Space Engineering Center for Extraterrestrial Natural Resources
the University of Pennsylvania	8093	Human/Robot/Sensor Integration Engineering Research Center
the University of Pittsburgh	8047	Center for Surface Stability of High Temperature Materials
Polytechnic University	8059	Center for Trans-Orbital Spacecraft Studies

List of Proposals sorted by University

Princeton University	8041	Advanced Propulsion Science and Technology
Purdue University	8001	Dynamic Systems Integration
Purdue University	8057	Space Electric Power Research Center
Purdue University	8097	Center for Advanced Engineering Materials
Rensselaer Polytechnic Institute	8012	Center for Advanced Engineering Materials and Structures for Space Applications
Rensselaer Polytechnic Institute	8043	Intelligent Robotic Systems for Space Exploration
Rensselaer Polytechnic Institute	8070	Center for the Future of Flight
Rice University	8075	Space Robotics Center
the University of Southern California	8088	Mechanical and Thermal Space Technology
the University of South Florida	8064	Center for Advanced Laser Sensor Technology
Stanford University	8102	Center for Transatmospheric Flight Studies
Stanford University	8111	Center for Space Robotics
Stevens Institute of Technology	8104	Center for Advanced Earth-Orbit Propulsion
the University of Tennessee Space Institute	8023C	Propulsion Space Technology and Research Center
Texas A&M University	8017	Center for Mechanics and Control of Flexible Space Structures
Texas A&M University	8067	Space Engineering Research Center for Regenerative Life Support Systems
Texas A&M University	8022	Integrated Energy and Processing for Propellants and Materials Manufacturing on the Moon
Texas Tech University	8103	Space Power Engineering Research Center
the University of Texas at Arlington	8054	Center for Large Space Structures (CLSS)
the University of Texas at Austin	8074	Center for the Integrated Analysis of Spacecraft Systems

List of Proposals sorted by University

the University of Texas at Dallas	8082	Center for Space Based Information and Communication Systems
the University of Toledo	8033	Center for Space Engineering Research in Cryogenics
Utah State University	8008	Center for Remote Optical Sensing in Space (CROSS)
the University of Utah	8010	Center for Advanced Space Engineering
the University of Utah	8052	Microwave and Millimeter-Wave Device Technology for Space Applications
Vanderbilt University	8011C	Center for Human Survival in Space: Low Gravity Biomedical Engineering and Technology
Vanderbilt University	8039	Center for Materials Technology in Space
Virginia Polytechnic Institute	8035	NASA Space Engineering Center: Durable Space Materials and Structures
the University of Virginia	8080	Space Engineering Research Center for Light Metallic Thermal Structures
Washington State University	8113C	Center for Control of Interfacial Transport Processes
Washington University	8051C	Center for Space Engineering and Science of Composite Materials
the University of Washington	8063	Center for Space Power and Propulsion
West Virginia University	8028	Robotic Assembly and Maintenance Modules in Space
the University of Wisconsin-Madison	8101	Space Cryogenics
the University of Wisconsin-Madison	8107	Center for Space Applications of Fusion Energy
Worcester Polytechnic Institute	8084	Non-Terrestrial Resource Processing
the University of Wyoming	8068	Composite Materials and Structures Space Engineering Research Center

Mrs. Morella. I would be very interesting in seeing what that report is that came out January if there is something in print about the analysis of it.

Dr. Rosen. We didn't provide a printed report. What we did is we asked all the university center directors to come in and to meet with us and to meet in a group and discuss problems, solutions to some of the problems they have had, and as it turned out, that was a very exciting meeting and the center directors getting all together at once fed on each other and they were able to see ways in which they could make their center better as a result of things that happened at other centers.

Mrs. Morella. Did each of them get a grant?

Dr. Rosen. Yes. We started off with about half a million dollars, and that will go up to about a million and a half on the average.

Mrs. Morella. Are there international students—not students—professors involved in this, too?

Dr. Rosen. You raise a very interesting question, Mrs. Morella. We started out the program by saying that we would restrict any participation, any direct financial participation by people who are not American citizens. Part of the reason for that is to encourage and increase the number of American graduate students and faculty members.

In looking at that whole situation, we think it probably is the right thing to do with the graduate students. It might be not quite right with respect to the faculty members, and so we are rethinking whether we ought to maintain that same constraint with regard to the faculty members.

Mrs. Morella. But you are going to keep it as far as the students are concerned?

Dr. Rosen. Yes. One of the purposes of——

Mrs. Morella. With the idea that they will be staying in this country?

Dr. Rosen. That is right.

One of the purposes is to not train engineers to go overseas.

Mrs. Morella. Right.

Dr. Rosen. The purpose is to keep them here.

Mrs. Morella. Fine. I don't want to usurp any more time.

Thanks, Dr. Rosen. Thank you, Mr. Chairman.

Mr. Nelson. Mr. Chairman, may I ask one question?

Mr. Perkins [presiding]. You certainly may. [Laughter.]

Mr. Nelson. In our commercial space launch bill that we passed, there is a provision in there that says that NASA needs to come up with a plan for research on helping modernize the fleet of commercial ELVs.

Where are you on that?

Dr. Rosen. We are in the process of working that, Mr. Chairman. We think that we can have a report to this committee in the middle of April.

We began the work at the end of December. We have involved industry heavily in the deliberations. We think it is appropriate, and we are looking for ways to industry, that in fact we deal with them.

We are now to the point where we have collected a considerable amount of data and are putting the report together, and we will be going back to industry. We are working closely with three industry groups, the AIA, COMSTAC, which is the Commercial Space Transportation Advisory Committee of the Department of Transportation, and with an ad hoc group of our SSTAC, Space Systems Technology Advisory Committee, which is dealing with low cost transportation.

So we are gathering up the information. We have got to go back to those groups and see whether or not we have got closure, whether they agree, whether everything we have done makes sense, and then we will provide the report.

Mr. Nelson. Is that in your bailiwick?

Dr. Rosen. Yes, it is.

Mr. Nelson. In your office?

Dr. Rosen. That is right, it is.

Mr. Nelson. Your report was due to us January the 15th.

Dr. Rosen. That is right.

Mr. Nelson. Why April?

Dr. Rosen. Well, we think that what you are really asking for is something that is going to have a major impact on the commercial space launch system, and we simply were not going to get that data together in time, and that left us with two choices. One choice was to provide an incomplete report, and the other was to do a good job and get it to you late, and we chose——

Mr. Nelson. You said you didn't start until December, the end of December.

Dr. Rosen. That is right.

Mr. Nelson. The bill was signed November the 15th.

Dr. Rosen. That is right. There was some discussion within the agency on who ought to do it, and it just simply took us time to get going.

Mr. Nelson. That is the kind of stuff we need to speed up. I mean, it wasn't that you didn't know that it was going to be there until November the 15th because it was part of that negotiating process that was going on, and that bill was passed by the Congress the middle of October. So October to January is three months. October the 15th to January is three months, and that is the kind of stuff we shouldn't constantly have to be on your back about, and yet NASA does it to us over and over and over, and we are just getting tired of it, and it means a lot to us.

Fortunately, we are getting the commercial launch business cranked up and we are really happy for that. We have got 26 signed payloads, but that was one of the reasons we put that in, that you can't keep—he is trying to solve the problem of Eastern Airlines, and one of the things he just told me outside the room is that you can't run an airline still running on old 727's. You have got to modernize your fleet, and that is what that was all about, modernizing the fleet.

Dr. Rosen. We agree with the importance of that, Mr. Chairman, and we want to put together a good report, and we will do that for you in April.

Mr. Nelson. Thank you.

Mr. Perkins. I guess Mr. Rohrabacher?

Mr. Rohrabacher. Just a couple of questions.

First of all, I just came from a meeting where you were talking with elected officials from other countries from Europe about our potential in space, and they were asking me about the Space Station. They were asking all of us. I just happened to be the one that got to answer the question. And they were asking us about the Space Station and about whether or not we wanted further cooperation from our Allies on this.

And I told them—and what I am asking you is to correct me if I am wrong on what I just told them, which was basically we want anybody who wants to do business eventually to come up there and do business on our Space Station.

Is that what we are going to be doing once that Space Station gets up there? We are going to offer an opportunity for anybody in the free world to come up and hook on and try to have a commercial enterprise?

Dr. ROSEN. That is one of the uses of the Space Station, will be for commercial aspects. I really don't have enough information, Mr. Rohrabacher, to say whether or not we would do that to anybody at any time.

My view of the Space Station is that it is going to be very crowded very shortly after it gets into orbit, and I would really prefer that the details of that question be given to Mr. Odom.

Mr. ROHRABACHER. All right. Let me ask you a question about your ELVs.

Do you know anything about a charge by American Rocket Company that they presented a plan to NASA and then all of a sudden there was an RFP put out that was basically mirroring their rocket design that they had submitted to you and basically in a method, in a way to undercut their effort as a commercial and private effort?

Dr. ROSEN. I have had some dealings with American Rocket Company, Mr. Rohrabacher. I don't believe it was exactly the way you expressed it, however.

Mr. ROHRABACHER. I am not expressing. I am asking you about it.

Dr. ROSEN. Okay.

No. What happened is that sometime ago when we put the Civil Space Technology Initiative together we felt it would be very important to include in that program some technologies associated with hybrid rockets. The reason we wanted to put that in there is that we felt during the Challenger accident, if we had known that there was a flaw in the solid rocket motor from the time of liftoff—because of the nature of the solid rocket motor there is nothing you could do—if we had known at liftoff. All we could do is cross our fingers and launch.

With hybrid rockets, however, you have the ability to turn them off. Essentially, a hybrid rocket is solid fuel and a liquid oxidizer. If you shut the valve and stop the liquid oxidizer, the rocket stops, and we felt that there had been considerable amount of technology that went on in the past into the 1960s, late 1960s, early 1970s, in those kinds of pistons, but they had not gone the rest of the way. We wanted to in CSTI take it the next few steps. So we were in the process of planning and released an RFP for technology associated with high reliable, large band kinds of pistons.

Now, there is an American Rocket Company, which is one of the small companies and wants to be a commercial ELV manufacturer based on hybrid technology. When we released the RFP, the President of that company contacted us and said that he could furnish all that technical information to us, on the one hand, and on the second hand, he said that what we were doing would hurt his business.

Mr. ROHRABACHER. Was his plan submitted or his ideas submitted to NASA before this RFP?

Dr. ROSEN. I don't believe so, Mr. Rohrabacher. I have no knowledge that anything was submitted by Am Rocket to us before that RFP came out.

Mr. ROHRABACHER. I won't take up any more of the committee's time, but if I have further questions on this I could submit them to you and you could give them back in writing?

Dr. ROSEN. I will furnish it for the record, yes.

Mr. ROHRABACHER. All right, great.

Thank you.

Mr. PERKINS. Well, does anybody else have any more questions at this stage?

[No response.]

Mr. PERKINS. Doctor, we appreciate very much your testimony today, and we look forward to seeing you at some appropriate time in the future.

Dr. ROSEN. Thank you very much.

Mr. PERKINS. And with that, I guess this committee meeting is adjourned.

[Whereupon, at 4:02 p.m., the subcommittee was adjourned.]

1990 NASA AUTHORIZATION

THURSDAY, MARCH 9, 1989

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met at 1:38 p.m. in Room 2318, Rayburn House Office Building, Hon. Bill Nelson, chairman of the subcommittee, presiding.

Present: Representatives Nelson, Sensenbrenner, Nagle, Packard, Torricelli, Brown, Johnston, McMillen, Rohrabacher, Morella, Schiff, Buechner, Walker, Lewis and Stallings.

Mr. **Nagle** [presiding]. This hearing will come to order.

Our chairman is momentarily delayed, and I will defer his opening statement to him until he arrives.

I understand our ranking minority member has an opening statement, and I would yield to him at this time for that purpose.

Mr. **Sensenbrenner**. Thank you very much, Mr. Chairman. It is a pleasure to serve under your leadership.

I would like to welcome our distinguished guest from Cornell, Dr. Sagan, and the NASA Assistant Administrator for the Office of Exploration, Dr. Franklin Martin, to today's hearing.

For those Members of the Subcommittee, including myself, who have been frustrated by the apparent lack of vision in the space program during recent years, today's testimony should provide a breath of fresh air. Today we have the opportunity to discuss NASA's long-range goals with the people responsible for identifying what missions are available and what we need to do to get there.

For those Members of the Subcommittee who have not yet seen this NASA publication, "Beyond Earth's Boundaries," let me suggest you request a copy from NASA and take a few minutes to page through the material. Within its covers, the Office of Exploration discusses four human exploration case studies for beyond the year 2000, the resources necessary to accomplish the missions, and the role of tomorrow's space station in achieving the next century's space successes.

There are a wealth of options, alternative scenarios, and unanswered questions as we proceed to examine what awaits us in space beyond the year 2000.

Mr. Chairman, I appreciate the effort of today's witnesses in contributing to that debate.

Mr. **Nelson** [presiding]. Thank you, Mr. Sensenbrenner.

Professor Sagan, you certainly need no introduction to this committee. We have had the pleasure of having you here before to give us exciting and visionary testimony. And your activities, your extensive writings, talking about manned missions way out into the solar system are well known. We are going to be very interested to hear what you are going to recommend specifically in the way of major goals for this Nation in its future space program going on well into the next century.

So, one of the things particularly we would like to know is if you are still enthusiastic about a human mission to Mars and your commentary about the international participation, your commentary about your latest thoughts on the fact of going to Mars together.

This last Tuesday, I had the occasion to speak to the Washington Business Roundtable, and I let it be known my preference for the manned mission to Mars in an international mission. As you know, that is what I wrote in the book that was published last summer as well.

So, our discussions with you are going to very nicely complement the testimony of Dr. Martin, who is going to be telling us about the activities of his Office of Exploration this year. I understand that he will be giving us some commentary about the ensemble of potential manned missions and about the studies that he has ongoing with regard to our activities into the future.

So, this is going to be an exciting hearing, and we are looking forward to it.

Professor Sagan?

STATEMENT OF DR. CARL SAGAN, PRESIDENT, PLANETARY SOCIETY

Dr. SAGAN. Thank you, Congressman Nelson.

There are a fair number of things I came prepared to talk about, but maybe I should just begin by answering directly what you have just asked me and then I will try to answer members' questions as best as possible. And if there is something I wanted to say that I am not asked about, maybe I will be permitted to interject it at the right time later.

Yes, I still am very enthusiastic about the prospect of a long-range goal for the United States to be the sending of men and women to explore the planet Mars in cooperation with citizens of other nations. I would like to explain why. I brought some slides, but I am still waiting for the carousel to put them in. But let me try to back up without it.

The main point of the slides, when I will have a chance to show them to you, will be that if we trace the history of NASA's great voyages of exploration and discovery, robotic missions, we find that they are closely coupled to the Apollo program.

When Apollo was going great guns, it was possible—here, I can show them as I talk, I hope. I may wind up putting in everything backwards. It will just take one second.

[Pause.]

Mr. NELSON. You folks are more intent than I have seen you in a long time. [Laughter.]

Dr. SAGAN. I will come to the slides in just a moment.

Let us just back up for a moment and ask what was the story during the Apollo years. During the Apollo years, NASA had a clearly articulated, easily understood, long-term goal, enunciated by the President of the United States. All parts of NASA were working toward that goal. Life sciences was oriented towards that goal. Propulsion was oriented towards that goal. Unmanned robotic exploration of the moon was oriented towards that goal. The field centers, industry, the military, NASA headquarters, the scientific community—everything was fitting together very nicely. Everybody knew what they were after. The parts added up to a whole.

Now, the reason for the Apollo program was certainly not the exploration of the moon. This is well understood. Apollo can only be understood in the context of U.S.-Soviet rivalry and nuclear confrontation at that time. Apollo was the American response to Soviet successes involving Sputnik and especially the first manned orbital flights of Yuri Gagarin and German Titov.

Here was an opportunity to leapfrog the Soviet successes, to demonstrate American capability in space. And note the important underlying theme: that the same rockets that put Soviets in Earth orbit and Americans on the Moon demonstrated the technology to carry nuclear weapons from one part of the world to another.

The subtext, the fundamental aspect of the Apollo program, was the nuclear arms race. As all the world knows, the United States won that race to the Moon. There is now no question about the ability of the United States to obliterate the Soviet Union or the ability of the Soviet Union to obliterate the United States. Therefore, a race in space between the United States and the Soviet Union makes no longer any sense.

At the same time, without an overriding political objective, it is hard to understand why the United States would make a commitment to some other long-term goal. And for that reason, I keep coming back to the conclusion that the next long-term goal must be political, and since it cannot be involved with rivalry, it has to be involved with cooperation.

But before I go on, let me just try to show in a few slides how powerful the influence of Apollo was on planetary exploration and exploration of the solar system.

So, if I can have the first slide. I will do it.

[Slide.]

We need a noise suppression circuit. I will try to talk loud. We will need the overhead lights down. And we will need that focused. Let me focus it.

Is that reasonably clear?

Okay. So, what we have here is the full panoply of American missions to the moon and planets.

I think it would be easier if that were closed.

Shown in yellow—well, first of all, there are three horizontal strips. The top strip is the decade of the '60s. The second strip is the decade of the '70s. The third strip is the decade of the '80s. This shows all successful missions.

You can see the Mariners, the Rangers, Lunar Orbiters, Surveyors, Apollos, Vikings, Voyagers, and Pioneers. Every one of the missions shown is a successful mission. I have not put down the unsuccessful missions.

And this is the panoply of historical American exploratory vehicles that have for the first time opened up the solar system to the human species.

Because of these missions, we have now examined every planet to Mercury to Uranus and if all goes well, by next August, Neptune at the very planetary frontier of the solar system.

All of this was done under the aegis of Apollo. Even though you did not have to go Mars or Jupiter in order to understand how to go to the Moon, it was a natural concomitant to Apollo technology. It was a relatively small incremental cost. It was very much to the benefit of the Nation and the human species.

You can see the last Apollo missions in the early '70s, and no U.S. missions after 1978.

For the last 11 years, after this historic sequence of exploratory ventures—I mean this will be in the history books a thousand years from now the same way that Dias and Vasco de Gama are in the history books—after that historic exploration of the solar system the United States has not launched one, after dozens of successful missions, not one since 1978.

We hope that this year will see the rebirth of the U.S. program of exploring the solar system.

So, this is one striking way in which we can see the importance of an overriding goal to the exploration of the solar system. No goal, no exploration.

Next slide.

[Slide.]

No, we will need the next slide. No, that's not how it's done.

Here is the amount, the percent of the Federal budget spent on planetary exploration as a function of time. And you can see that it was always a very small fraction. But it peaked in the middle '60s. That was preparatory to Apollo. There was a secondary peak around '73–'74. That was the last gasp of Apollo and the principal funding for Viking. And it has been wiggling away since then at an all- time low fraction of the Federal budget.

Mr. NELSON. Are you including in that the Apollo expenditures?

Dr. SAGAN. No. No. This is by planetary here. I really mean planets, not the Moon.

Mr. NAGLE. And are we talking about a 25 percent—no, we're talking about one-quarter of a percent?

Dr. SAGAN. That is correct. I am also having a little difficulty focusing on it from here.

Next slide, please.

[Slide.]

Here now are the two curves plotted together. The total NASA authorization, in purple, and the planetary program or, let's say, the Office of Space Science and Applications program, in yellow. And obviously, to different scales.

But what I want to show is how they go up and down together, the one anomaly being the cost of Viking, which is that 1973-74 peak, in yellow, for OSSA budget.

The lesson here is—again in budget as in programs—when there is an overriding national goal, you get these extraordinary space science bonanzas.

Then the final point I wanted to make is that essentially all of the missions that were launched after the demise of the Apollo program nevertheless were designed and most of them authorized in the Apollo years.

Next slide, please.

[Slide.]

So, here is Viking, Voyager, Pioneer, Venus, and the yet-to-be-launched Magellan, Galileo and Mars Observer. And you can see the year of the study, the year of approval, and the year of launch. And the year of approval for all that have been launched, the latest is 1975, Viking and Voyager are still in the Apollo years.

If I can have the lights now. Thank you.

So, this is a demonstration of what we all knew qualitatively, that it is the national goal which is connected with political objectives that embraces the presidential interest that has led to those extraordinary accomplishments.

It is conceivable that there could be such a program without international cooperation, a purely national goal. But I have great difficulty imagining how in the absence of an international element, cooperative or competitive, there could be the kind of sustained commitment that we are talking about, because these missions have many years from design to execution.

I look at the changing relations between the United States and the Soviet Union, and I see a need, explicitly stated in both countries and throughout the world, for these two superpowers—these two nations that have boobytrapped the planet with almost 60,000 nuclear weapons—to demonstrate their ability to work together for a positive human future: high technology, something everyone on Earth can understand, something positive for the next century and millennium, and the long-term program of the exploration of Mars seems to me to be—and it's very hard to imagine a more exciting program, in part because Mars itself is so exciting, vastly more interesting than the Moon. It is a dynamic world, the world which once was very Earth-like, with bodies of water and rivers and very different from its present ice-age environment.

The question of past or present life is still open. The prospect of past organic matter on Mars is open. Its geologic terrain is extremely varied. Its surface area is equal to the land area of the Earth and, therefore, provides an opportunity for exploration for many years into the future.

There are practical benefits in studying Mars, including the fact that here we are pushing and pulling on our global environment, and isn't it important to understand how an Earth-like world got changed into such a bleak environment (in terms of what unprotected human beings need)? That is information we need to have.

So, what I advocate, what the Planetary Society that I am here partly representing advocates, is a concerted program of cooperation, not just between the United States and the Soviet Union but also the European Space Agency and Japan and other emerging space-faring nations, to: A, determine what is necessary for humans to travel to Mars—that is, Earth-orbital tests of long duration human space flight;

Secondly, a phased series of explorations of Mars. We have landed with Viking only in two spots, and they were chosen for their dullness—dullness equals safety. We would like to have roving vehicles, perhaps balloon probes as the Soviet 1994 mission seems to be heading up to. We would like to have a return sample from Mars.

Before we go to Mars, we would like to have a piece of Mars in the laboratory to examine. And then sometime, maybe in the first or possibly second decade of the 21st century, a grand exploratory mission of humans to Mars led jointly by the United States and the Soviet Union, with all of that exploratory data coming in to the evening television sets, if that's what we want.

The idea of a vehicle from Earth containing Americans and Soviets and Europeans and Japanese wandering down one of those ancient river valleys, looking for a glint of white from some fossil in the bank or trying to understand why the rivers dried up, that seems to me an extremely exciting prospect.

We pool costs, we pool talent, we pool global interest, we work towards a benign long-term political goal. And that, it seems to me, makes sense in the same way that the Apollo program made sense for the United States in the early 1960s.

This clarifies and makes specific what the goal of the space station is. The principal goal of the space station in this model, if the United States were to accept this long-term goal, is to understand how safely to have humans in space within the timescale it takes to get to Mars and back is about one to two years, something like that.

The Soviets, I know the committee members are aware, have already been in space for a year. This is a typical travel time to Mars. There is no other obvious long-term objective that takes a year to go somewhere.

The Soviets have a great concentration on Mars in their unmanned robotic program right now, unlike the United States which has a scaled-down Mars Observer which is the only Mars program that is approved for the future, and even that is small potatoes compared to what we did in 1976.

The Soviets have a very ambitious mission just about to do its stuff on Phobos, the innermost moon of Mars, right now, and a much more dual-launch mission in 1994 to Mars itself.

They have the Energia launch vehicle, which is of much greater lift capability than the United States has, put those pieces together, they are substantially farther along than the United States is. It is clear that the Soviets will go to Mars, and the question is will the United States do so as well. I think we ought to.

So, I took more time than I thought, but that is my answer to your question, Mr. Chairman.

[The prepared statement of Dr. Sagan follows:]

Documents to Accompany Oral Statement

By Professor Carl Sagan

President, The Planetary Society

For the Subcommittee on Space Science and Applications

U.S. House of Representatives Committee on Science, Space, and Technology

March 9, 1989

ACCOMPANYING DOCUMENTS

1. Biography of Dr. Sagan
2. The Planetary Society
3. The Mars Declaration
4. Advancing American-Soviet Cooperation in the Exploration of Mars
5. Conference Report: Emphasizing the International Agenda in US Space Policy
6. "World Watch:" A Planetary Society Statement on CRAF/Cassini
7. Statement of the Space Science Working Group, subscribed to by The Planetary Society

DR. CARL SAGAN

Carl Sagan is the David Duncan Professor of Astronomy and Space Sciences and Director of the Laboratory for Planetary Studies at Cornell University. He has played a leading role in the Mariner, Viking and Voyager expeditions to the planets, for which he received the NASA Medal for Exceptional Scientific Achievement; the Prix Galabert, the international astronautics prize; the NASA Medal for Distinguished Public Service (twice), the Konstantin Tsiolkovsky Medal of the Soviet Cosmonautics Federation; and the John F. Kennedy Astronautics Award of the American Astronautical Society. His scientific research has enhanced our understanding of the greenhouse effect on Venus, dust storms on Mars, the organic haze on Titan, the origin of life, and the search for life elsewhere. Dr. Sagan has served as Chairman of the Division for Planetary Sciences of the American Astronomical Society, as President of the Planetology Section of the American Geophysical Union, and as Chairman of the Astronomy Section of the American Association for the Advancement of Science. For 12 years he was Editor-in-Chief of *Icarus*, the leading professional journal devoted to planetary research. He is currently President of the Planetary Society, a 100,000-member organization which is the largest space-interest group in the world; and Distinguished Visiting Scientist, Jet Propulsion Laboratory, California Institute of Technology.

In addition to more than 600 published scientific papers and popular articles, Dr. Sagan is author, co-author or editor of more than twenty books, including *Broca's Brain*, *Comet*, *Contact*, and *The Dragons of Eden*, for which he was awarded the Pulitzer

Prize. He was responsible for the Pioneer 10 and 11 plaques, and the Voyager 1 and 2 interstellar records, messages about ourselves sent to possible other civilizations in space. His Emmy and Peabody Award winning television series Cosmos became the most widely watched series in the history of American public television, and has now been seen in 60 countries by over 300 million people. The accompanying book, also called Cosmos, was on the New York Times bestseller list for 70 weeks and is the best-selling science book ever published in the English language.

In recent years, Dr. Sagan and his colleagues have been engaged in research on the long-term consequences of nuclear war, uncovering previously unsuspected dangers for our civilization and our species. Partly for this work, he has been given the Annual Awards for Public Service of the Federation of American Scientists and of Physicians for Social Responsibility, as well as the Leo Szilard Award for Physics in the Public interest of the American Physical Society. Dr. Sagan has also received the Explorer's Club 75th Anniversary Award "for achievements in furthering the spirit of exploration," the Joseph Priestley Award "for distinguished contributions to the welfare of mankind," and the Honda Prize "for contributions towards . . . a new era of human civilization."

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THE PLANETARY SOCIETY

The Planetary Society is the largest space interest group in the world with more than 125,000 members in over 70 countries. Founded in 1980 by Carl Sagan, Bruce Murray, and Louis Friedman, The Planetary Society provides its members with many benefits and sponsors a wide variety of activities. Members receive a bi-monthly color magazine, The Planetary Report, which covers developments in space exploration with spectacular pictures and timely articles. The Society holds regional, national and international conferences, lectures for members and major exhibits such as Planetfest '89, which will celebrate the upcoming Voyager 2 encounter with Neptune. Members can purchase pictures, slides, and the latest books at special rates. The Society has actively advocated continued planetary exploration with such missions as Magellan, Galileo, Mars Observer and CRAF/Cassini; and the Society hopes to persuade the spacefaring nations to adopt the human exploration of Mars as a major long-range goal.

The success of the Society has enabled us to support a few low-cost but critical scientific projects, including asteroid discoveries, research in new Mars surface exploration projects and the construction of a quarter-million channel receiver and computer system that is now searching for signals from advanced civilizations outside our solar system. Membership in The Planetary Society provides individuals with an opportunity to participate in the greatest adventures of our times--the exploration of the planets and the search for extraterrestrial life.

The Mars Declaration

Mars is the world next door, the nearest planet on which human explorers could safely land. Although it is sometimes as warm as a New England October, Mars is a chilly place, so cold that some of its thin carbon dioxide atmosphere freezes out at the winter pole. There are pink skies, fields of boulders, sand dunes, vast extinct volcanos that dwarf anything on Earth, a great canyon that would cross most of the United States, sandstorms that sometimes reach half the speed of sound, strange bright and dark markings on the surface, hundreds of ancient river valleys, mountains shaped like pyramids and many other mysteries.

Mars is a storehouse of scientific information – important in its own right but also for the light it may cast on the origins of life and on safeguarding the environment of the Earth. If Mars once had abundant liquid water, what happened to it? How did a once Earthlike world become so parched, frigid and comparatively airless? Is there something important on Mars that we need to know about our own fragile world?

The prospect of human exploration of Mars is ecumenical – remarkable for the diversity of supporting opinion it embraces. It is being advocated on many grounds:

- As a potential scientific bonanza – for example, on climatic change, on the search for present or past life, on the understanding of enigmatic Martian landforms, and on the application of new knowledge to understanding our own planet
- As a means, through robotic precursor and support missions to Mars, of reviving a stagnant U.S. planetary program
- As providing a coherent focus and sense of purpose to a dispirited NASA for many future research and development activities on an appropriate timescale and with affordable costs
- As giving a crisp and unambiguous purpose to the U.S. space station – needed for in-orbit assembly of the interplanetary transfer vehicle or vehicles, and for study of long-duration life support for space travelers
- As the next great human adventure, able to excite and inspire people of all ages the world over
- As an aperture to enhanced national prestige and technological development
- As a realistic and possibly unique opportunity for the United States and the Soviet Union to work together in the spotlight of world public opinion, and with other nations, on behalf of the human species
- As a model and stimulant for mutually advantageous U.S./Soviet cooperation here on Earth
- As a means for economic reconversion of the aerospace industry if and when massive reductions in strategic weapons – long promised by the United States and the Soviet Union – are implemented
- As a worthy application of the traditional military virtues of organization and valor to great expeditions of discovery
- As a step towards the long-term objective of establishing humanity as a multi-planet species
- Or simply as the obvious response to a deeply felt perception of the future calling.

Advances in technology now make feasible a systematic process of exploration and discovery on the planet Mars – beginning with robot roving vehicles and sample return missions and culminating in the first footfall of human beings on another planet. The cost would be no greater than that of a single major strategic weapons system, and if shared among two or more nations, the cost to each nation would be still less. No major additional technological advances seem to be required, and the step from today to the first landing of humans on Mars appears to be technologically easier than the step from President John F. Kennedy's announcement of the *Apollo* program on May 25, 1961 to the first landing of humans on the Moon on July 20, 1969.

We represent a wide diversity of backgrounds in the fields of science, technology, religion, the arts, politics and government. Few of us adhere to every one of the arguments listed above, but we share a common vision of Mars as a historic, constructive objective for the technological ambitions of the human species over the next few decades.

We endorse the goal of human exploration of Mars and urge that initial steps toward its implementation be taken throughout the world.

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Advancing American-Soviet Cooperation in the Exploration of Mars

from "World Watch", *The Planetary Report*, Mar/Apr 1989

by Louis D. Friedman and Susan Lendroth

"LET'S GO TO MARS—TOGETHER." Since our President, Carl Sagan, first issued this call in 1984, The Planetary Society has enthusiastically embraced the goal of Mars exploration led by the United States and the Soviet Union. We have played a key role in focusing the attention of the public and policymakers alike on the need for a well-planned space program leading to human exploration of Mars early in the next century.

Some have misunderstood our advocacy, thinking it too narrow or too single-minded. (Dr. Sagan dealt with these and other criticisms in the November/December 1988 *Planetary Report.*) That the Mars goal is indeed in the mainstream of space policy has recently become evident by wide-ranging and varied support.

Rethinking Space Policy

The US presidential campaign and transition to a new administration provided many opportunities to consider space policies. Several presidential candidates—including the new chairman of the NASA authorizing subcommittee in the US Senate, Albert Gore—supported our Mars goal (see the September/October 1988 *Planetary Report*). Although President Bush has yet to declare himself, a little noted but apparently carefully considered statement in the Republican party platform asserted: "a resurgent America, renewed economically and in spirit, must get on with its business of greatness. We must commit to a manned flight to Mars *around the year 2000* (italics ours) and to continue exploration of the moon." We have no way of knowing if this declaration resulted either directly or indirectly from The Planetary Society's testimony to the party's platform committee, but it certainly did follow our Mars advocacy. The simple endorsements by both the Republican party and the Reverend Jesse Jackson were particularly telling.

As each new administration prepares to take office, many groups submit studies to the transition team in hopes of influencing the President's policies. The Center for Strategic and International Studies (CSIS), a Washington "think tank," submitted the first of two major space policy studies. The chairmen were Brent Scowcroft, who has since been named President Bush's National Security Advisor, and John McElroy, Dean of Engineering at the University of Texas at Arlington. They determined that US space policy coordination is a broken system that needs fixing by White House leadership. They were influenced by the internal NASA "Leadership Report" (Ride study), which offers alternative goals for the US civil space program. The CSIS study concluded that human exploration of Mars should be the United States' long-term goal; that it should be a prime purpose of the space station (along with US technological competitiveness); and that it should be international, following a carefully planned and negotiated series of steps involving both US allies and the USSR. The CSIS also stated that the civil space program must be structured to serve major US national objectives: education, environment, competitiveness and exploration.

The other study, conducted by the National Academies of Science and of Engineering, was chaired by Dr. H. Guyford Stever, the former head of the National Science Foundation. It too called for presidential leadership in setting space goals and recognized that any major space initiative must be political in origin. It concluded that human exploration of the solar system should be the guiding principle behind any such initiative and that it was *the* right goal for the space station.

In December 1988, NASA's new Office of Exploration issued its first report to the Administrator. It studied several human exploration scenarios: establishing a lunar base, landing on Mars' moon Phobos, a Mars mission, and the settlement of Mars. All have as the major goal human exploration of Mars. And just recently that office noted that US-Soviet cooperation is the best and most likely way to carry out the program. This year the office will begin studying international partnership in mission design.

Success?

Admittedly, we don't all agree on *how* to reach the goal of landing humans on Mars. But our differences are secondary; if we can agree to an international expedition, the scientists and engineers of the involved nations can and will figure out how to get there.

Have we won? Some say the Society should declare victory and assume that the Mars goal is in place. Others point out that the hard steps have not yet been taken—the space station has not been redirected, the US has no launch vehicle policy suitable for human missions to Mars, the US-USSR Space Cooperation Agreement (see the January/February and May/June 1987 *Planetary Reports*) is still too little and too slow, and even the robotic precursor steps to Mars are unapproved and unfunded. But the widespread recognition of our position gives us reason to believe that we are making considerable progress.

Looking Backward: How We Put Mars Back on the Agenda

In June 1984, when US-Soviet cooperation in space was moribund and relations between the two countries nearly non-existent, The Planetary Society organized a meeting in Graz, Austria, of leading Soviet and US planetary scientists to discuss bilateral cooperation in planetary missions. This meeting led to new steps in data exchange among *Viking* and *Venera* scientists as well as informal contacts in the *Vega* and *Phobos* missions and, most important, paved the way for official government action, especially the renewal of the 1972 intergovernmental agreement on US/USSR cooperation in space.

In September 1984, Dr. Sagan's article "The Case for Mars" appeared in *Discover* magazine, outlining both the scientific reasons to return to the planet and the envisioned goal of international cooperation in peaceful ventures: "Suppose the people of Earth are one day fortunate enough to discover new leaders in Washington and Moscow dedicated to a new beginning and to seal that new beginning they embark on a dramatic joint enterprise—something like the *Apollo* program but with cooperation, not competition, the goal."

That same month Carl Sagan and Louis Friedman testified to the Senate Committee on Foreign Relations about international cooperation in space. Dr.

Friedman stated, "A cooperative US/USSR program in planetary exploration that might lead to human flight to Mars would be of enormous significance to the cause of global security and international stability."

By October 1984, through the initiative of Senator Spark Matsunaga (D-HI), the US Congress had passed—and the President signed—a Joint Resolution urging renewal of the space cooperation agreement. By then The Planetary Society was promoting the goal of international cooperation in space—specifically in missions to Mars.

Building Mars Momentum

The Planetary Society's program gained momentum with a series of symposia, some directly addressing Mars exploration, others, like the symposium "The Potential Effects of Space Weapons on the Civilian Uses of Space" (cosponsored by the American Academy of Arts and Sciences) in January 1985, discussing the future use of space. There Academician Roald Sagdeev, Director of the Institute for Space Research of the Soviet Academy of Sciences, suggested a joint Mars Sample Return-Rover project. Panel Chairman Dr. Bruce Murray, Society Vice President and former Director of the Jet Propulsion Laboratory, summed up the discussion with a alternative to space weaponry: "We should be looking toward a future in which humans will go to Mars."

To mark the 10th anniversary of the *Apollo-Soyuz* linkup, The Planetary Society cosponsored the conference "Steps to Mars" with the American Institute of Aeronautics and Astronautics in July 1985. Participants included the *Apollo-Soyuz* astronauts and cosmonauts; Roger Bonnet of the European Space Agency; Senator Matsunaga; Astronaut Sally Ride; Thomas Paine (now a Director of the Society, then Chairman of the US National Commission on Space); and James Beggs, then Administrator of NASA, who spoke hopefully of international cooperation in space, remarking, "Ironically, perhaps Mars, the 'war god,' could become a powerful instrument for peace."

The Planetary Society addressed Mars exploration from every angle. Technical considerations were analyzed in a 1985 Society-commissioned report by the Science Applications International Corporation that studied human missions to the Moon, a near-Earth asteroid, and Mars. It provided the first post-*Apollo* cost estimate of a piloted Mars mission. The Society also cosponsored "Case for Mars" conferences in Boulder, Colorado, that brought together professionals and enthusiasts developing ideas for human Mars exploration.

Louis Friedman presented a technical description of a program built around a Mars goal, "Towards Becoming a Multi-Planet Species," to the 1985 International Astronautical Federation Congress. Bruce Murray touched upon the political need for human flights to Mars in his article "Civilian Space: In Search of Presidential Goals" for *Issues in Science and Technology* in 1986. Dr. Sagan described the potential impact on society of such flights in "USA and USSR: Let's Go to Mars—Together," read by the 65 million readers of *Parade* magazine. The article appeared in the Congressional Record, was excerpted in *Pravda* and was reprinted worldwide.

Additionally, several special issues of *The Planetary Report* were devoted to Mars exploration, such as "Humans on Other Worlds," March/April 1985; "*Viking*: the Tenth Anniversary," July/August 1986; and "Exploring Mars," May/June 1987.

In the summer of 1987, US and Soviet space scientists and policy-makers met via satellite link-up in the Society-sponsored Spacebridge "Together to Mars?" For four hours experts from the two countries discussed Mars exploration. Although they reached no consensus as to whether or not life exists on Mars or where the best landing sites are located, everyone agreed that pooling resources and efforts would enhance not only future missions but also global cooperation. The panelists also defined the value of joint robotic missions to characterize the martian environment. That fall PBS televised nationally a one-hour special entitled "Together to Mars?" based on the Spacebridge; similar programs were shown on Soviet and Japanese television.

Triumphs Despite Trials

In April 1987, when NASA delayed the *Mars Observer* two years from a planned 1990 launch, Planetary Society members wrote over 10,000 letters of protest to Congress and NASA. Although the 1990 launch date was not reinstated, NASA delayed the mission over strong congressional objections.

The Society broadened its campaign by circulating a Mars Declaration listing twelve cogent reasons for visiting our neighboring world. The Mars goal captured the imagination of a strikingly diverse group of US leaders. Initial signatories included leaders of peace groups and retired Army, Navy, Air Force and Marine general and flag officers; astronauts and religious leaders; labor and industry executives; politicians and poets; Nobel laureates and sports figures; ambassadors, university professors and former presidential advisors; former cabinet and sub-cabinet members; and every former NASA Administrator since the agency's founding except the then incumbent. Subsequently, tens of thousands have signed the Mars Declaration, with hundreds of new signatures arriving daily.

US scientists are now working on the Soviet *Phobos* mission, and Soviet scientists will work on the US *Mars Observer* mission; three bills are now before Congress setting the goal of human exploration of Mars and encouraging US/USSR cooperation toward that goal; and more than 30 editorials urging these objectives have appeared in such publications as *The New York Times, The Los Angeles Times*, the *Atlanta Constitution, US News and World Report* and the *Christian Science Monitor*.

In 1988 The Planetary Society presented testimony supporting the US planetary exploration program, in particular the proposed Comet Rendezvous Asteroid Flyby, to the Senate Committee on Commerce, Science and Transportation; urged members to support Project Pathfinder, a technology development program for future space missions, including a piloted Mars mission; and supported development of Mars ballooning for implementation on the Soviet *Mars 94* mission.

The Planetary Society continues to advocate cooperation over competition in space, long-term mission goals rather than dubious short-term objectives, and a peaceful focus for the combined energies of the world's technological super powers. The time may finally be right to commit to the future, to commit to the human exploration of Mars.

Louis Friedman is Executive Director of The Planetary Society. Susan Lendroth is the Society's Manager of Events and Communications.

EMPHASIZING THE INTERNATIONAL AGENDA IN U.S. CIVIL SPACE POLICY

On December 8-10, 1988, some 35 leaders and specialists experienced in space policy from the United States, Canada, France, Germany and the European Space Agency met in Washington, D.C., to discuss "developing the international agenda for space exploration". The meeting was organized by the Space Policy Institute of The George Washington University and The Planetary Society. An agenda for the meeting and a list of participants is attached.

This group of experts reached one clear consensus: SPACE INITIATIVES THAT INVOLVE SUBSTANTIAL INTERNATIONAL COLLABORATION CAN FURTHER MAJOR U.S. SECURITY, POLITICAL, AND ECONOMIC INTERESTS AND ARE NEEDED TO RESPOND TO TWO IMMEDIATE CHALLENGES TO THIS COUNTRY.

This first challenge is the rapid, potentially disastrous changes to the global environment caused by growing human activity on Earth. Space-borne instruments, Earth-based observations and studies of other Earth-like planets are crucial for a focused program now labeled "Mission to Planet Earth." This mission should be international in conduct and content, and deserves high national priority.

The second challenge is the effective and innovative Soviet initiative to build international relationships in highly visible programs of space exploration and so demonstrate the U.S.S.R.'s technical prowess and new international openness. With its Eastern and Western European partners the Soviet Union flew by Halley's Comet, deposited balloon payloads in the atmosphere of Venus, and is sending a spacecraft to explore Mars and its asteroid-like moon Phobos. The Soviets have in essence established a permanent presence of humans in Earth orbit, and continue to push back the frontiers of long-duration human flight. Future Soviet plans make interntional involvement in U.S.S.R. science missions a high priority objective. Their initiative, enhanced by the new atmosphere of glasnost, is focused on Western Europe and the United States, but includes Japan, Canada, Europe, South Asia and Latin America.

So far the United States has responded guardedly to Soviet overtures, while traditional U.S. allies are entering into new relationships with the U.S.S.R. It is in the interests of the United States to regain its prominence in international space science and exploration, thereby influencing the future direction of the world's space activities and reaping the many benefits of international cooperation.

In order to do this, the United States needs to build upon three decades of cooperative experience with its traditional partners, and particularly upon the recently created space station partnership with Europe, Japan, and Canada. Meeting participants agreed that all spacefaring countries--the United States, the Soviet Union, Europe, Japan, Canada, and other nations--should be involved in planning and carrying out future large scale space activities such as Mission to Planet Earth and exploratory voyages beyond Earth orbit.

Meeting participants recognized that, in order for international space initiatives to be effectively linked to broader American interests and objectives, both around the world and at home, strong presidential leadership is required. That leadership is needed to focus current U.S. space activities and is more essential to their policy effectiveness than are increased budgets, altered institutional arrangements, or new international structures--all of which, however, will be needed.

The President-elect has already endorsed a Mission to Planet Earth, the purpose of which is to provide vital information for policy decisions affecting all aspects of the world environment and economy and the health of its citizens. But a U.S. initiative is needed to make that program international. An international Mission to Planet Earth would begin with coordination of operations and data collection for the more than two dozen existing and scheduled Earth observing spacecraft of many nations. The mission would expand to include polar platforms contributed by the the United States, Europe and Japan, and potentially the Soviet Union. Early in the 21st century, it could encompass coordination of geostationary spacecraft of the major space powers.

An important first step was taken when a NASA-promoted space agency coordinating committee for the 1992 International Space Year (ISY) adopted the Mission to Planet Earth as a primary ISY objective. In this and other forums the United States can more effectively encourage the Soviet Union to respond with specifics regarding its participation. The roles of Europe, Japan and other spacefaring nations, the participation of developing countries, and the need for altered or new international mechanisms could be identified in the context of an enlightened global initiative related to Mission to Planet Earth.

The ability of the United States both to take an active stance in responding to Soviet space science initiatives and to indicate future directions for the alliance-based space station partnership is limited by the lack of an exploratory goal that provides a cohesive focus for American efforts in space. A broad array of groups studying the U.S. civil space program have concluded that its single biggest deficiency is the lack of a coherent exploratory goal. Expanding human activity and presence beyond Earth orbit was added as a long-term objective of U.S. space policy earlier this year, but no compelling goal nor specific objectives have yet been enunciated to carry out that policy. The Republican party, in its 1988 platform, recommended that a "resurgent America, renewed economically and in spirit, must get on with its business of greatness. We must commit to a manned flight to Mars around the year 2000 and to continue exploration of the moon." All at the meeting agreed that Mars was the long-term goal for human exploration, although a specific strategy for getting there was not discussed.

However, there was a consensus on the need to link current U.S.-Soviet interactions regarding solar system exploration with interactions with U.S. allies. Two related White House actions seem required. One is to broaden the scope of current U.S.-Soviet cooperation to allow the conduct of joint studies and the consideration of more ambitious, collaborative missions, both automated and ultimately with human crews. The other is to imbed these bilateral discussions and studies in a broader multilateral context. This would build on the space station partnership and thus engage other spacefaring countries as well as the United States and the Soviet Union in defining the directions for space exploration in the early 21st century.

If there was one message that came from most participants in the meeting, it was the need to begin discussing multilateral partnerships in complex space undertakings as soon as possible. All countries are experienced enough to recognize that exploratory discussions of potential collaboration on future missions do not constitute on any side a commitment to either collaboration or to particular missions. But issues such as matching expectations, roles, and contributions in major projects; making national commitments on different time frames and through different political and budgetary processes; and developing a rational and consistent approach to questions of technology transfer can only be addressed on the basis of extended, frank discussions among potential partners. These discussions should not be only at the technical level; involvement by political officials at an early stage is essential. Many participants suggested that the international regime for Antarctic activities was a particularly useful model in developing a multilateral approach to human exploration of the solar system.

Based on the above considerations, the organizers of the meeting--that is, The Planetary Society and the Space Policy Institute of The George Washington University--put forth the following recommendations:

1. the United States should intensify its leadership effort to make Mission to Planet Earth a truly global undertaking. A presidential endorsement and active presidential support for this effort would greatly facilitate its success;

2. the U.S.-U.S.S.R. space cooperation agreement of April 1987 should be amended to allow for the conduct of joint studies of solar system exploration missions and possible future multilateral missions; and

3. the United States should take the initiative in organizing a multilateral U.S.-U.S.S.R.-Europe-Japan solar system exploration working group. This group would consider the most appropriate

steps in a multi-decade enterprise of robotic and human exploration and expansion beyond Earth orbit and identify the synergistic roles that the major spacefaring countries, and eventually others of the world's nations, might play in that enterprise.

LIST OF PARTICIPANTS

"Developing the International Agenda for Space Exploration"

December 8-10, 1988

Lew Allen	Director, Jet Propulsion Laboratory
James Beggs	NASA Administrator, 1981-1985
David Bodde	Executive Director, Commission on Engineering and Technical Systems, National Research Council
Roger Bonnet	Director, Scientific Programs, European Space Agency
Joanne Clayton	Senior Staff, Aeronautics and Space Engineering Board, National Research Council
James Carpenter	Chairman, Space Issues Group, Bush Campaign
Alain Dupas	Le CNES; Centre d'Etudes des Relations entre Technologies et Strategies, Ecole Polytechnique, Paris
John Dutton	Dean, College of Earth and Mineral Sciences, Pennsylvania State University
Burton Edelson	Foreign Policy Institute, Johns Hopkins University; Associate Administrator for Space Science and Applications, NASA, 1982-1987
W. M. Evans	Deputy Secretary, Space Policy Sector, Ministry of State for Science and Technology, Canada
Daniel Fink	Former Chairman, NASA Advisory Council
Dietmar Frenzel	Director, Office for Space Programs, BMFT, Federal Republic of Germany

Louis Friedman	Executive Director, The Planetary Society
Gene Giberson	Assistant Director, Jet Propulsion Laboratory
Albert Gore	U.S. Senate
Sam Keller	Deputy Associate Administrator for Space Science and Applications, NASA
Marty Kress	Senate Committee on Commerce, Science and Transportation
John Logsdon	Director, Space Policy Institute, George Washington University
Tim Lynch	The Planetary Society
Hans Mark	Chancellor, University of Texas; Deputy Administrator, NASA, 1981-1984
Frank Martin	Assistant Administrator for Exploration, NASA
John McLucas	Chairman, NASA Advisory Council; Chairman of the Board, Questech, Inc.;
Michael Michaud	Director, Office of Advanced Technology, Department of State
James Morrison	Center for Strategic and International Studies
Bruce Murray	California Institute of Technology; Former Director, Jet Propulsion Laboratory; Vice President, The Planetary Society
Harvey Meyerson	U.S. International Space Year Association

Noreen Noonan	Chief, Science and Space Branch, Office of Management and Budget
Kenneth Pedersen	Associate Administrator for External Affairs, NASA
Herman Pollack	Space Policy Institute, George Washington University; Chairman, Task Force on International Relations on Space, NASA Advisory Council, 1986-1987
Ian Pryke	Head, Washington Office, European Space Agency
Brad Mitchell	Policy Development Staff, Office of President-Elect George Bush
Jeffrey Rosendhal	Space Policy Institute, George Washington University; Assistant Associate Administrator (Science), NASA, 1982-1987
David Rossi	Orbital Sciences Corporation
Richard Sade	Center for Space and Advanced Technology
Carl Sagan	Cornell University; President, The Planetary Society
Harlan Smith	McDonald Observatory, University of Texas
Richard Smith	Principal Deputy Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs, Department of State
William Smith	Staff Director, House Subcommittee on Space Science and Applications
H. Guyford Stever	Chairman, NAS/NAE Committee on Space Policy; Science Advisor to the President, 1974-1977

World Watch

As many of our members know, the numerically noteworthy date of 8/8/88 marked the tenth year without a planetary launch by the United States. Next year will, we hope, finally break this pattern with the launches of Magellan *to Venus in April and* Galileo *to Jupiter in October.* Mars Observer *will follow in 1992. No other US planetary missions have been approved.*

NASA has plans to launch the Comet Rendezvous Asteroid Flyby mission in 1995, with the Cassini *mission to Saturn and Titan close on its heels in 1996. If these missions are started now, the decade of the 1990s could once again see the US with a vigorous space program, again working closely with the Europeans and possibly exploring Mars with the Soviet Union.*

*The Planetary Society strongly supports the CRAF/*Cassini *mission and encourages the new administration and Congress to approve the project this year.—Louis D. Friedman*

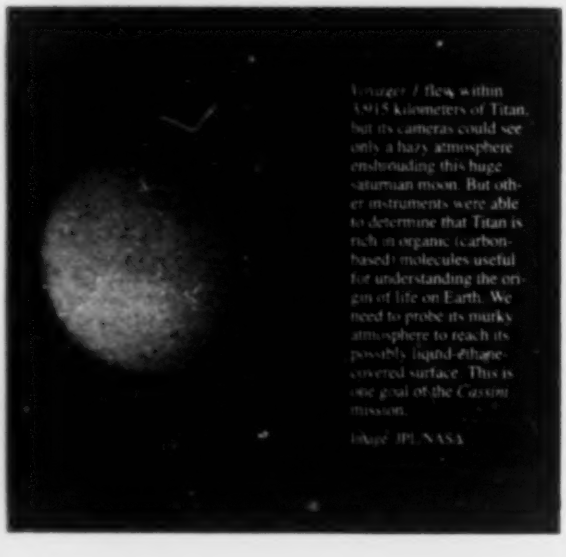
NASA's Office of Space Science and Applications has given the CRAF/*Cassini* mission its highest priority for a new start in the fiscal year beginning in October 1989 (FY 90). This project combines two missions that NASA has long studied: the Comet Rendezvous Asteroid Flyby, known by the acronym CRAF, and *Cassini*, a Saturn orbiter to be built by NASA and a Titan probe to be built by the European Space Agency (ESA). Both missions will use NASA's new *Mariner Mark II* spacecraft, so combining them into a single project will greatly reduce the total cost.

This project is part of NASA's budget proposal for FY 90, now in the hands of the Office of Management and Budget (OMB). In 1989 OMB must approve it, and it must be accepted by both the President and the Congress before it officially becomes part of NASA's program.

ESA recently furnished a new incentive for OMB and presidential approval when scientific committees and its governing body selected the *Cassini* probe for a FY 90 new start. *Cassini* had been competing with three astronomy missions and another planetary mission (the French/Soviet *Vesta* mission that would have flown by several asteroids and a comet). ESA made a difficult and highly significant choice—first, simply to select a planetary mission and second, to choose the United States as a partner. This demonstrated confidence in NASA marks an important step in rebuilding European-American relations in space, which were greatly strained several years ago when the US cancelled its spacecraft for the once-joint *Ulysses* mission to study the Sun. ESA's actions should help NASA's efforts to get a new start for CRAF/*Cassini* in FY 90.

This mission will make a multipronged attack on understanding the distribution of organic material in the solar system. Cometary nuclei, some types of asteroids, several other moons and Titan are all rich in carbon-based compounds. (The great significance of comets and Titan to the field of exobiology was described in the November/December 1987 *Planetary Report*.) In its rendezvous with a comet, CRAF will have hundreds of days to make detailed studies far beyond those made by the *Vega* and *Giotto* craft that flew by Halley's Comet. It will send a penetrator into the comet's interior, as well as conducting remote sensing experiments.

Cassini will send an orbiting craft to spend four years studying the ringed planet Saturn, briefly visited by *Pioneer* and *Voyager* spacecraft. At Titan it will deploy a probe to make a leisurely three-hour descent through the satellite's atmosphere, measuring its structure and composition. It might even survive to land on the surface.—*Tobias Owen, State University of New York, Stony Brook*



Voyager 1 flew within 3,915 kilometers of Titan, but its cameras could see only a hazy atmosphere enshrouding this huge saturnian moon. But other instruments were able to determine that Titan is rich in organic (carbon-based) molecules useful for understanding the origin of life on Earth. We need to probe its murky atmosphere to reach its possibly liquid-ethane-covered surface. This is one goal of the *Cassini* mission.

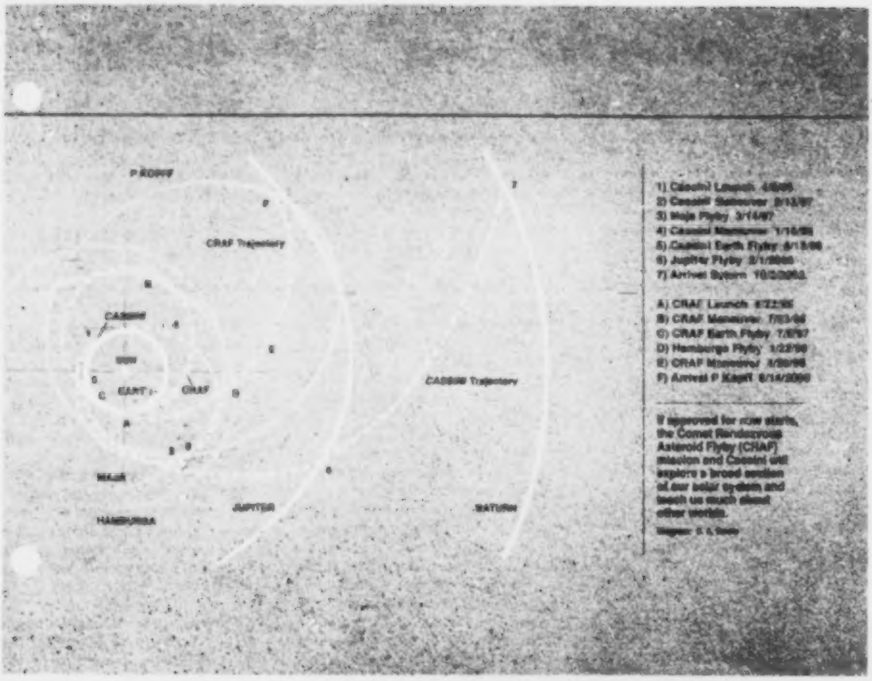
Image: JPL/NASA

NEW START—A Govern

"New Start" is the United States government's equivalent of a starter's pistol. It is the signal to government agencies and private industry to commit money, to begin work and to build hardware for a project. Every planetary mission must receive an individual new start in the federal budget before it can move forward. Since 1980 only the *Magellan* mission to Venus and the *Mars Observer* have received new starts, but both have been delayed and scaled down.

NASA may propose CRAF/*Cassini* for a new start. To receive it, the administration must propose the mission in its budget submitted to Congress. Then the mission must negotiate this tortuous path through the US Congress:

1. The Senate and House Budget Committees must accept the budget submitted by


P KOPFF
CRAF Trajectory
CASSINI
SUN
EARTH
CRAF
MAJA
HAMBURGA
JUPITER
CASSINI Trajectory
SATURN
1) Cassini Launch 4/8/96
2) Cassini Maneuver 2/13/97
3) Maja Flyby 3/14/97
4) Cassini Maneuver 1/10/98
5) Cassini Earth Flyby 8/15/98
6) Jupiter Flyby 2/1/2000
7) Arrive Saturn 10/2/2002
A) CRAF Launch 8/22/95
B) CRAF Maneuver 7/03/96
C) CRAF Earth Flyby 7/8/97
D) Hamburga Flyby 1/22/98
E) CRAF Maneuver 4/30/98
F) Arrival P Kopff 8/14/2000

If approved for new starts, the Comet Rendezvous Asteroid Flyby (CRAF) mission and Cassini will explore a broad section of our solar system and teach us much about other worlds.

Diagram: S. & Davis

mental Starter's Pistol

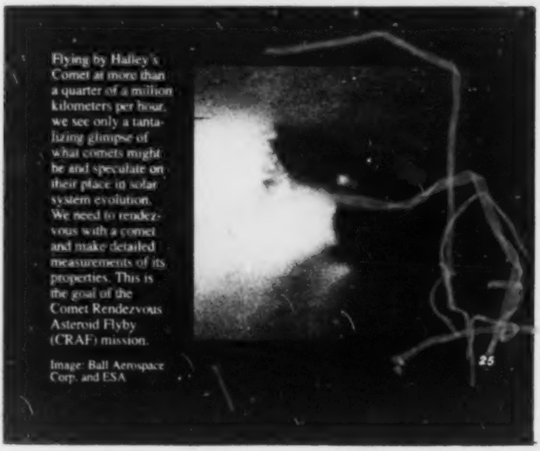
NASA and give the new start high priority.

2. The Senate Committee on Commerce, Science and Transportation and the House Committee on Science and Technology must authorize the new start.

3. The Senate and House Appropriations Committees must give their approval.

4. The full Congress must approve their committees' budget, authorization and appropriation actions. If the administration fails to propose the mission, then Congress can add it as a new start.

We encourage all members to express interest in the CRAF/*Cassini* project by sending letters or mailgrams to their Representa- and Senators asking them to support the request for a new start with the Authorizing and Appropriations Committees.
—*LDF*



Flying by Halley's Comet at more than a quarter of a million kilometers per hour, we see only a tantalizing glimpse of what comets might be and speculate on their place in solar system evolution. We need to rendezvous with a comet and make detailed measurements of its properties. This is the goal of the Comet Rendezvous Asteroid Flyby (CRAF) mission.

Image: Ball Aerospace Corp. and ESA

SOCIETY Notes

[redacted]

The Planetary Society's campaign for US/Soviet cooperation in planetary exploration received an enormous boost at the recent US/USSR Planetary Working Group meeting. American scientists met with their Soviet counterparts to plan and coordinate future planetary missions. After years of the Society advocating such cooperation, NASA invited Soviet scientists to work with the US *Voyager*, *Magellan* and *Galileo* missions; the Soviets invited US scientists to assist with *Phobos* and *Mars '94*, and the two nations compared their Mars Rover and Sample Return studies with an eye to making them more international.

On November 8th, the Society hosted a reception in Washington, DC, for the Working Group to celebrate its progress as well as the prospects for increased international planetary exploration. —*Louis D. Friedman, Executive Director*

[redacted]

The Planetary Society is pleased to announce the appointment of Adriana Ocampo as a Senior Consultant. Dr. Ocampo, a member of the technical staff at the Jet Propulsion Laboratory, co-chaired the Society's Mexico City Workshop in September 1987, helped to lay the groundwork in her native Argentina for the Society's southern hemisphere SETI (Search for Extraterrestrial Intelligence) project, and recently helped to organize a meeting of the Pan American Space Organization in Washington, DC. —*LDF*

[redacted]

On March 16, 1989, The Planetary Society will sponsor a public presentation at NASA's Johnson Space Center in Houston, Texas. Local members will hear US and Soviet planetary scientists discuss planetary exploration. Call our events calendar telephone lines for more information. —*Susan Lendroth, Manager of Events and Communications*

[redacted]

In a public lecture held October 30th in Austin, Society President Carl Sagan told an overflow audience that a joint human mission to Mars can provide the cohesive goal needed to revitalize NASA and restore the US role in planetary science and exploration. The lecture was held in conjunction with the 20th annual meeting of the Division for Planetary Sciences of the American Astronomical Society. —*SL*

[redacted]

The Planetary Society, the Association of Science and Technology Centers (ASTC), The Smithsonian Institution's National Air and Space Museum, the International Association for the Astronomical Arts, and the USSR Union of Artists have joined together to sponsor a five year space art project.

This spring the exhibit of Soviet and American paintings will highlight festivities surrounding the *Phobos* encounter with Mars and its largest moon. In August, selections from that show will travel to the Society's Planetfest '89 in Pasadena. The paintings will then go to the Reuben Fleet Space Theater in San Diego and then, under the auspices of ASTC, begin a national tour.

The Planetary Society and the Association of Science and Technology Centers are seeking corporate sponsors to join with us in the exhibit. We'll inform our members later this year when the travel schedule is set.

—*Charlene M. Anderson, Director of Publications*

[redacted]

Society membership has reached an all-time high of 125,000. This includes over 10,000 members in Canada, 1,500 in Australia, 500 in the United Kingdom; several hundred members each in Italy, Sweden, Spain, France, Switzerland, West Germany, and the Netherlands; and sizable numbers in 30 other countries. We're proud to have members in over 80 nations. Welcome aboard!

—*Cindy Oas, Data Processing Manager*

[redacted]

On December 8-10, 1988, Washington, DC, was the site of a meeting of space policy leaders entitled "Developing the International Agenda for Space Exploration," cosponsored by The Planetary Society and the Space Policy Institute at George Washington University. Society members and the general public were invited to a symposium on the prospects for international cooperation. Society President Carl Sagan gave the keynote address. Society Vice President Bruce Murray, Roger Bonnet of the European Space Agency; Harlan Smith of the University of Texas, Austin; W. M. Evans of the Ministry of State for Science and Technology, Canada; and John McLucas of QuesTech, Inc. discussed opportunities open to the new Bush administration.

—*Tim Lynch, Director of Programs and Development*

[redacted]

The Society's Volunteer Network enables members to participate at the local level. Over 75 enthusiastic, hard-working regional coordinators representing 38 US states and 9 other countries lead volunteers in setting up displays, distributing brochures and circulating the Mars Declaration. Some coordinators hold regular meetings. For more information and local contacts, send your name, address and phone number to me c/o The Planetary Society. —*Marshalle Wells, Volunteer Network Coordinator*

[redacted]

The Planetary Society
65 N. Catalina Avenue
Pasadena, CA 91106

Call for an updated events calendar:
(818) 793-4328 east of the Mississippi
(818) 793-4294 west of the Mississippi

General calls:
(818)793-5100

Sales calls ONLY:
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STATEMENT SUBSCRIBED TO BY THE PLANETARY SOCIETY

SPACE SCIENCE WORKING GROUP

Statement of the Space Science Working Group on the FY 1990 Budget Proposed by President Reagan

The Space Science Working Group (SSWG) commends NASA and President Reagan for submitting a FY 1990 budget which advances several areas of importance to the university space science community. We are particularly encouraged by the proposed new start for the CRAF/Cassini mission and the essential increases in the research and analysis components of the Office of Space Science and Applications (OSSA) budget.

These positive steps notwithstanding, the SSWG is concerned about several aspects of the budget as submitted. The OSSA portion of the budget is extremely tight, with little or no flexibility for unanticipated events or opportunities. A major program has been "zeroed" - the Shuttle Test of Relativity Experiment (STORE). Two other initiatives, modest in cost but large in importance, were not included in the budget request: the Earth Probes spacecraft series (the first of which would monitor the temporal and spatial variations in the Earth's ozone layer) and a program to place U.S. experiments on international missions.

Of even greater concern to the SSWG is the fact that the proposed budget runs counter to a well-thought-out policy, enunciated by NASA and supported by Congress, that at least 20 percent of the agency's combined R&D and space flight budgets be allocated to space science and applications. This policy was established by the Congress to guarantee the availability of funds sufficient to maintain the minimally necessary level of research support, including payload flight opportunities. Only through this policy can it be ensured that space science, the basis of America's future in space, will not be asked to assume the burden of cost over runs or administrative planning errors in other parts of the space program.

We continue to believe in the soundness of previous NASA and Congressional reasoning that set the minimum budgetary investment in space science at the 20-percent level. When President Bush and Congress consider the NASA budget, we urge them to restore the appropriate balance in our nation's civil space program. Specifically, the $182 million needed to return to the 20-percent level for space science and applications would permit the restoration of STORE and initiation of the Earth Probes series, would enhance international scientific cooperation in space exploration, and would provide needed increases to mission operations and data analysis budgets. These modest additions to the space science program would go a long way towards ensuring a fully balanced program of space science and applications and would accelerate American efforts to regain leadership in space.

January 30, 1989

c/o Association of American Universities • Suite 730 • One Dupont Circle
Washington, D.C. 20036 • 202/466-5030

Mr. **Nelson**. Members of the Committee, Mr. Nagle?

Mr. **Nagle**. No questions, Mr. Chairman.

Mr. **Nelson**. Mr. Schiff?

Mr. **Torricelli**. No questions, Mr. Chairman.

Mr. **Nelson**. Mr. Torricelli?

Mr. **Torricelli**. Thank you, Mr. Chairman.

Professor Sagan, you should know that the vision you bring to the committee may be new, and some of your ideas might appear to members to be refreshing. But the proposal in fact has been before the committee before. And indeed there is a great deal legislatively that the committee can do to bring to pass that you have suggested.

A few years ago, when President Reagan was meeting with Mr. Gorbachev for the first time, Members of this Congress suggested that the President raise with Mr. Gorbachev, at the suggestion of Soviet authorities who indicated that the response would be favorable, that the President invite Mr. Gorbachev to jointly begin to plan how it is our countries could work together towards a Mars mission. The President saw fit not to take that invitation.

Last year, the effort began legislatively. The legislation that I introduced and that this committee passed which did not make its way into the combined legislation with the other body, we specifically proposed that a commission be formed of Americans to approach other possible international partners to begin to plan, to track, to conceptualize what a joint mission might be like, so that we could plan with NASA, ESA, and the Soviets could plan the respective programs of how they might contribute towards that goal.

I think it is worth noting now that that legislation has been introduced again, now that I will attempt again to place it into an authorization bill, that for whatever enthusiasm the members may express about the concept, the real measure of course is not the speeches we make on the issue but whether or not they join in sponsoring and whether or not they cast those votes, because all indeed that we are trying to do is to explore the possibilities.

Perhaps the Soviets won't take the invitation. Perhaps the Japanese and the Europeans aren't really interested. But we owe it at least to ourselves to determine whether, consistent with our national security and our own objectives, they will take an invitation and whether there are common elements and whether or not the things that we are doing in our respective programs today complement that goal.

That is what I would like to see us do. And I am using this opportunity in addressing our chairman and other members of the committee in the hope that they will join in that goal.

We could, of course, begin by following this opportunity today and by marking up this legislation, but by going ahead in our own authorization process in the future, by addressing it in depth and working its way through this institution. That is my hope. It is my hope that your being here today will support and that we can realize that goal.

I would like, Mr. Chairman, to follow those comments by several questions, if I could, if you find it appropriate at this time.

First, Professor, is it your impression that perhaps the Soviets in recent months have had a change of focus, that there have been reports that perhaps they have taken a different look at lunar missions in the future rather than their current Mars emphasis.

Do you put any stock in those reports?

Dr. SAGAN. Thank you, Representative Torricelli. I appreciate your previous remarks prior to the question, and the question also. But I just want to say I was very heartened by your proposal for a national Mars commission and very much hope it does get enacted into legislation.

On the question of Soviet interests, it should be remembered that there were several specific statements by General Secretary, now President Gorbachev, proposing such missions to the United States.

For example, I myself heard one at the Soviet embassy during the Washington summit in which Mr. Gorbachev was making a presentation to a large number of Americans, many of considerable eminence, and in the question period he was asked what steps could be taken to bring the two nations together. The first step out of his mouth was a joint U.S.- Soviet manned Mars mission.

So, it wasn't, "Do you think that this is a good idea?" It was, "Of all the possible steps, which do you think ought to be taken?" And that was the first one he proposed.

And there were several others, other occasions on which Mr. Gorbachev and other high Soviet officials have made similar statements.

However, the executive branch has been so reluctant, so sluggish in its responses that the Soviets can, I think, justly conclude that the United States may not be serious about this, and they may be scaling back the arena of their interests.

I can tell you, though, that I am confident that this is still high on their list of priorities. What is open is whether they will do it on their own or with other Nations not involving the United States or with the United States. But they would be unwise not to examine the lunar options as well.

Mr. TORRICELLI. Is there a reevaluation going on, in your judgment, in the Soviet Union?

Dr. SAGAN. I don't think it's an issue of reevaluation. The issue has powerful political components, as I tried to say before. The United States' lack of readiness to cooperate with the Soviets on this issue forces the Soviets to scale back what they have in mind. And I think that is all we are saying.

If you look at the proposals from Mr. Gorbachev, you see they started out at a very high plane of joint manned and womaned missions, and when the United States gave no adequate response on that, then they were scaled down to a joint rover/sample return robotic mission. And when no response from the United States came on that, then for a while we haven't even heard that.

But I believe it is true that were the United States to show some sign of interest on this, there would be quick, positive Soviet response.

Mr. TORRICELLI. Indeed, the Soviets have made every attempt, I think, to make that clear. In my years in the Congress I have never introduced a piece of legislation which I have found to have been read more widely outside of the United States than it was read within the United States, from embassy officials to the Soviet Academy of Sciences to cosmonauts who have come to America, they have made a point of visiting my office to each provide their own individual endorsement.

My fear at this point is that with our inability to simply say yes, the Soviets for their own planning, whether it is a soil return mission, further exploratory missions, or in planning their own allocation of resources to develop technologies for a manned mission, begin to operate on the assumption that there will not be an American component.

So, our ability to plan to our own advantage, our ability to influence what those missions might be like, becomes limited. The Soviets soon have to reach the critical time juncture when they say if we're going to do a soil mission, we begin now to plan it alone, we start making commitments outside of this relationship. And clearly we are now approaching that time.

The Soviets not yet having announced a soil return mission, I take it that that time must be coming fairly soon when they start setting some public goals.

Are you aware of any kind of time frame in which they are operating, in which they are going to want to make judgments about the timing of a soil return mission?

Dr. SAGAN. I think they are very busy right now with mission operations for Phobos and the design of the 1994 mission. I suspect the United States may have a year, maybe even two years, before the Soviets make their decision on sample return missions. And as you know, there are vigorous research programs now by NASA to examine such programs, such missions as well.

The two nations are proceeding in parallel. They haven't yet intersected on this, but all it requires is a single page from the White House or even the NASA Administrator if he were able to act on his own, to make the intersection.

Mr. TORRICELLI. One of the frustrations, as the Administration seeks the opportunities to obtain the high ground in world opinion—and that we agree is the redefining of relations between the United States and the Soviet Union is not simply a case of the United States responding to Mr. Gorbachev's initiatives but has good faith on our part—it is partially of our design, this is such a tremendous opportunity for the world to see that not only can we come together but we can come together at American invitation and not simply at Soviet invitation.

Dr. SAGAN. Absolutely.

Mr. TORRICELLI. There would be a tremendously lost opportunity if we continue to allow time to pass.

Dr. SAGAN. I agree.

Mr. TORRICELLI. Let me if I could, Professor, to just ask two questions that are relevant as this committee looks itself at our own Mars efforts.

First, the judgment that are being made within NASA that both the space station and, in their judgment, to a similar extent a return to a lunar emphasis should be priorities, preliminary priorities of the United States with a Mars goal.

I understand and accept the rationale of the space station for the development of that technology and even in the design of a program.

Would you comment, in your judgment, about a return to the Moon and its relevance to the eventual Mars goal?

Dr. SAGAN. Yes. Let me address that directly and then I will just make a remark about the space station.

I am concerned that the Moon is not a way station to Mars, but a dead end, that the resources needed to not just go to the Moon but establish a base. That is very expensive. And that means that we will not be exploring Mars for many decades, with realistic estimates of the NASA budget.

The claim that you have to go to the Moon to test out the technology for going to Mars does not hold water. You can test and probably better the technology to get to Mars in Earth orbit and the technology on Mars on the Earth. The Moon is not a very Martian environment. It is very static. There is no air. Mars has winds, and there are many different respects in which they're different. So, I don't think that argument actually makes sense.

But the Moon is a default position. For example, the Pathfinder request by NASA was cut in half. That cut in half, if it were sustained in a systematic way, virtually guarantees that we can't go to Mars, at least on the sort of timescales that we are talking about.

On the space station, there is no question that you need a space station in order to do the Mars mission that we are talking about. You have to assemble the interplanetary transfer of vehicle or vehicles in Earth orbit. You need an infrastructure to do that. Beyond that, as I said before, you need to test out long-duration space flight. Can it be done safely in a year or two-year mission in zero gravity; or do you have to spin up the spacecraft, in which case we need to practice spinning up spacecraft in Earth orbit and see if there are physiological problems of that sort?

So, space stations for those functions are absolutely clear-cut and make sense in this context. On the other hand, I think it is fair to say that NASA's primary orientation for the space station, at least until very recently, has been the will-o-the-wisp of profitmaking industrial activities in near-Earth microgravity, and there is no evidence that that ever in the foreseeable future would pay for itself.

What's more, microgravity-oriented space stations fight the kind of space stations that you need for the functions that I was talking about.

But there is some sign—and I know Dr. Martin is planning to talk about it—of NASA giving strong emphasis now to human physiology in Earth orbit, which I think is just the right function for space station.

Mr. TORRICELLI. Finally, Professor, aside from the questions with which I think we are familiar of the physiology, as you look today at the investments that we are making in a variety of NASA programs, the technologies are being developed, which are the principal technologies that are required to envision a Mars mission are not currently being adequately pursued, in your judgment, even absent the judgment to undertake the mission? For those of us who would like to assure the preparation is being done even without that decision, what other technologies should receive emphasis?

Dr. SAGAN. If there were a go-ahead right now—let's pick a case contrary to fact and one that I do not advocate—not only was there a go-ahead right now but it was somehow a kind of crash program, a big rush to get to Mars. The only launch vehicle we had was shuttle. To construct that space vehicle in Earth orbit takes 20, maybe 25, shuttle payloads put up and all glued together.

That is asking a lot. A heavier launch vehicle is certainly part of the technology that would be useful.

The Soviets are talking about electric or solar electric propulsion or nuclear propulsion for missions to Mars. How serious that is, I don't know. I just know that they have made presentations at International Astronautical meetings in which they have laid that stress.

Certainly, the idea of spun and despun space craft in Earth orbit with long-duration crews, that has to be worked on. People working together in confined spaces for very long periods of time, that has to be worked on.

But I personally think that the step from where we are now technologically to what is necessary to get to Mars is less than the step that was required between President Kennedy's speech in 1961 announcing the Apollo program to the landing on the Moon in 1969.

Mr. TORRICELLI. Probably significantly less.

Dr. SAGAN. Significantly less, yes.

Mr. TORRICELLI. Of course, work on nuclear power systems and on development of an additional American heavy launch capability are of course both being done. In your judgment, not adequately so, considering where we should be in looking to the future toward interplanetary missions?

Dr. SAGAN. Not at a sufficient pace. And I do not want to advocate the idea of nuclear propulsion, but merely to point out that it is talked being about by the Soviets.

Mr. TORRICELLI. It needs to be studied.

Dr. SAGAN. It has to be studied. That's right.

Mr. TORRICELLI. Well, Professor Sagan, let me simply conclude by saying that among the plethora of problems in our country today, there is probably in my judgment none more serious than the fact that we have attained somehow a position of being a Nation of rather limited vision at this point in our history. We are plagued by willingness to think small rather than big, both of which are direct contradictions to our heritage.

Your being here today in no small way, at least for this committee's purposes, helps in our attempts to reverse that, to regain initiative, to understand where we are, the potentials of where we can go, and to take the lead internationally in doing so.

So, I appreciate your being here today, and you have done a great deal to help me and my efforts, and I hope to convince my colleagues to become a part of all the picture you have tried to paint here today for us.

So, I thank you.

Thank you, Mr. Chairman.

Dr. SAGAN. Thank you, Mr. Torricelli.

Mr. NELSON. Thank you, Mr. Torricelli.

Indeed, Mr. Torricelli, you have been one of the most persuasive of the committee, and I do not need to remind you that we included within the NASA authorization bill coming out of this subcommittee last year the Mars commission, took it to the floor, took it all the way to the Senate, and under the threat of veto from the White

House it was excised from the NASA authorization bill. Perhaps we will have a different fate come this year.

Mr. Schiff?

Mr. **Schiff**. Professor Sagan, my name is Steven Schiff. I am a new member of the committee and the House at this time. I am grateful to have the opportunity to ask you a couple of questions.

First, I just can't resist asking one sort of science-fiction question but, I hope, more realistically than that. I can't help but recall that in H.G. Wells' "War of the Worlds" the humans won because the Martians became infected with biological viruses and bacteria on this planet.

More realistically, the Europeans brought the gift of smallpox to the New World when they came several hundred years ago.

I am kind of wondering, is infection, either our human life infecting a life form on Mars, if it exists, or bringing back an infection. Is that a major concern in the idea of space exploration?

Dr. **Sagan**. By no means is it science fiction, Mr. Schiff. The two U.S. landers, the two Viking landers that landed on Mars in 1976 and that contained, among other instrumentation, devices to look for microbial life, had been thoroughly sterilized before launch, baked in ovens for long periods of time to kill every bug inside. And there were two reasons for that:

One, if terrestrial microbes hitchhiking to Mars on the spacecraft then worked their way into the life-detection apparatus, we would have a false positive. We would think we had detected life on Mars when we had only detected one of our own bugs that went along for the ride. That would be a very expensive failure and would confuse things terribly for subsequent missions. So, that was one reason, and the sort of operationally most important reason.

But another reason was that if it turned out that there was indigenous life in Mars, we didn't want to confuse those guys with bugs from Earth until we had studied them.

In fact, the results from the Viking landers were that at those two spots separated by 5000 kilometers down to a depth of about ten centimeters, which is only how deep we dug, there was not the faintest hint of any microbes.

The story might be different at different places or if we dug deeper. But right now, the bulk of the evidence and certainly the prevailing scientific opinion is that there is no reason to expect contemporary life on Mars.

Mr. **Schiff**. A couple more down-to-earth questions also. Do you have an estimate of the total cost of a manned exploration of Mars?

Dr. **Sagan**. It's about the cost of a single major strategic weapons system. So, you can——

Mr. **Schiff**. Any particular strategic major weapons system in mind?

Dr. **Sagan**. Well, roughly, MX. You can make the comparison of the human good from the two systems. And certainly much less than SDI. More than an aircraft carrier group. It's between SDI and a carrier group.

Mr. **Schiff**. Okay. I actually have some idea of what we're talking about now. [Laughter.]

In terms of that cost, I have heard the Space Station Freedom criticized to some extent on the grounds of do we want to be paying for a manned space station, given budget crunches and so forth, when robotics could do almost as much. I have heard that advanced.

Do you support the—first of all, I take it you support manned exploration. I believe that is what you have been emphasizing here; is that right?

Dr. SAGAN. Let me just give you a little background on that. I am someone who opposed starting the Apollo mission because I viewed it only in terms of exploration of the Moon, and I argued that whatever we wanted to find out about the Moon we could do it a lot more cheaply with robots, including bringing samples back. But at that time, I had not focused on the political reasons for Apollo.

I was also one of those who was strongly opposed to ending the Apollo program because once we had this extremely powerful tool working, let's, for heaven's sake, do the science.

And a very, I think, poignant and telling fact is that the last human to land on the moon was the first scientist to land on the moon. As soon as the scientists got there, they realized the program was completely worthless and closed it down.

It was a political program from the beginning, and we managed to get some science out of it, but it wasn't primarily scientific.

If science is what we are after, I say do it with robots. But there are other goals, political, social, historic goals, and I think the amount of rejoicing on the Earth from an American and a Soviet robot shaking hands on Mars would be significantly less than from an American and Soviet citizen shaking hands on Mars.

I think the idea of a new relationship between the two nations, the idea of a new chance for the human species on Mars works only for people. So, to say again, if we are only concerned with science, I say send the robots. But if we believe there are significant historical, social, and political objectives, then it might make sense to send people.

As far as things done in Earth orbit, except for this I think there is much too much an emphasis on manned and womaned space flight. They are much more expensive, and as we saw with Challenger, it has very tragic risks. Well, I could say some more, but that gives you at least a flavor of my answer to that question.

Mr. SCHIFF. Would you encourage us to support the funding of the space station Freedom, the manned space station, at the present time?

Dr. SAGAN. If we have in mind that we are going to want to send people to some more distant places in the solar system, then we have to have a space station in order to test out our ability to have humans work in space.

If we think we're not going to do go that, if we're not going to send people to the moon or to an Earth-crossing asteroid or to Mars, then I claim that there is no function for humans in Earth orbit.

Military reconnaissance, weather satellites, looking at the Earth as a planet, astronomical observations, any of those functions, deploying communications satellites, can be done better and much more cheaply and much more safely by robots.

Mr. SCHIFF. All right. I have just a couple more questions, Dr. Sagan.

With respect to the Soviet Union, it would be wonderful, of course, to have as many countries as possible sharing the technology and cost and making mutual contributions. I do not disagree as a matter of philosophy.

But for example, is there nothing in terms of national security that would give you concern in terms of our working closely with the Soviet Union, in terms of aerospace information that their military might receive?

Dr. SAGAN. Right. So, this is the issue of technology transfer. And it must, of course, be addressed.

The first thing to recognize is that the Soviets—this is a technology in which the Soviets are a world leader, and on many of the issues I mentioned before—heavy-lift boosters, long-duration space flight of humans, and exploration of Mars—they are ahead of us.

So when we start worrying about technology transfer, we have to, in this case, recognize that it goes both ways. I am not saying which way the net flow would be. But it certainly goes both ways, and I would say there is a lot to learn from the Soviets as well as doubtless vice versa.

The other thing to recognize is that if we are really concerned about technology transfer, there are ways to design missions so that they don't involve, and let me give an example.

An important step along the way to a human mission to Mars is the rover return sample mission that I mentioned earlier. Now, if we were extremely worried about technology transfer, consider the following mission design. One of the two nations—let's say it's the United States—is in charge of the rover. The other of the two Nations—let's say it's the Soviet Union—is in charge of the return sample mission.

So, if all goes well, the United States rover lands on a safe place on Mars and then wanders—imagine it with wheels or tractor tread, something like that—wanders to very exciting places, grabs samples, bags them, labels them, photographs them, takes data along the way, accumulates this fantastic library of rocks and soil samples, arrives at the rendezvous place.

The Soviet return sample mission lands. There is no technology handed over. Plastic bag technology is all that gets handed over. And then the Soviets bring the samples back to Earth and they are distributed to American and Soviet scientists. That is a zero technology transfer method of doing it.

Notice also that each nation is pretty well protected against some failure of dedication or technological failure of the other. Suppose the U.S. rover does everything perfectly, arrives at the rendezvous spot, no Soviet return sample mission. They exploded on the way or didn't get to Mars or something.

Well, lots of data have been taken along the way. The samples are not going to decay. We know precisely where they are. They will wait for us. At some later time we will send some other mission to recover those samples.

Now, imagine the failure the other way. The Soviet return sample mission lands, but the U.S. rover with the samples is stuck in a sand dune somewhere and never shows up for the rendezvous. The Soviet return sample mission then takes a grab sample right there at the landing spot, which is by no means the most interesting place on Mars, but it is Mars, and brings the material back to Earth and something has been rescued out of that.

So, it's possible to design minimized technology transfer scenarios which also protect each nation against the other kinds of failures from the other.

Mr. **Schiff**. I have one last matter, Dr. Sagan.

I too would like to see improved relations with the Soviet Union, but I am concerned that if we rush to improve relations with certain countries, that we may tend to look the other way at some of our differences.

For example, we are rushing, in my opinion, to improve relations with the People's Republic of China, and our State Department appears to be taking a low profile on what is happening in Tibet right now.

I am wondering if you are concerned that a rush to shake hands, the American astronaut to shake hands with the Soviet astronaut on Mars, might cause us to look the other way the next time the Soviet Union might want to decide to march into someone's country here on Earth.

Dr. **Sagan**. I think that both nations are imperfect, that both the United States and the Soviet Union and the People's Republic of China and Britain and France and just about any nation that I can think of have not just serious deficiencies but have committed crimes. And yet, we all have to live together on the same planet, a fragile planet, an increasingly vulnerable planet, a planet in which what threatens us can only be obviated, the problems can only be solved, if we all work together—despite all the bad stuff that we've done in the past.

I certainly don't think that if we have some cooperative Mars exploratory relationship with the United States and the Soviet Union marches back into Afghanistan or Iran or something like that, that we should close our eyes. And I don't think there is a chance that we would in fact.

But certainly not. That doesn't give them free run to do whatever they want because we are cooperating on such an issue. But I think in the long run the interest of the planet requires that we start a new kind of cooperative relationship.

I would also like to say that there are extraordinary things happening in the Soviet Union right now that any lover of freedom ought to applaud. And they are revolutionary. They are more revolutionary compared to the Soviet system than anything that has happened here in the last 100 years.

It is not guaranteed how long that will last, especially if there is no response by the United States. I think it powerfully in the American interest to keep the Gorbachev revolution going and some degree of cooperation with the Soviets is a way to encourage it.

So, I would put it the other way around and say that it is in the United States' self-interest to have nondangerous major kinds of cooperation with the Soviet Union, and Mars exploration is one of the best I can think of.

Mr. **Schiff**. Thank you, Mr. Chairman.

Mr. **Torricelli**. Would the gentleman yield?

Mr. **Schiff**. Mr. Chairman, I am prepared to yield the rest of my time.

I will yield to the gentleman, yes.

Mr. **Torricelli**. Thank you. Only for an observation, if you would.

You will recall that of course this is not the first time that Soviet-American space cooperation has been sought, and was once attained. And while America was fighting in Vietnam and our soldiers were fighting against weapons supplied by the Soviet Union we were planning a Soyuz-Apollo mission, which flew indeed as Vietnam was falling.

We did not compromise our principles or our security, change our foreign policy nor, interestingly, did they, because we had joint scientific interests. We were able to separate the politics in the extreme example from the science.

No one is of course anticipating, I hope, that that state of affairs arises again in conflict, but it shows that indeed if you are interested in science and in cooperation, even in the most extreme forms of conflict relations can continue and we as a political system can do so without compromising our most basic principles.

Mr. **Nelson**. Indeed, the experience of this gentleman is that space is the unique environment in which political adversaries on Earth can come together to cooperate. And we have seen that in a number of arenas, and that was the agenda item of this committee's trip which was led by Bob Walker and myself when we went to the Soviet Union in October of 1985 and, by the way, discussed with the then-president of the Soviet Union the host of potential items, not the least of which was the joint mission.

Mr. Johnston?

Mr. **Johnston**. No questions, Mr. Chairman.

Mr. **Nelson**. And I might point out, by the way, that that last scientist, the only scientist to land on the moon then became a politician.

Dr. **Sagan**. Oh, he was from the beginning.

Mr. **Schiff**. And of course from New Mexico, too, Mr. Chairman. I didn't want to say it until you brought that up. [Laughter.]

Thank you, Mr. Chairman.

Mr. **Nelson**. Mrs. Morella?

Mrs. **Morella**. Thank you.

Thanks, Mr. Chairman.

Professor Sagan, it is always a pleasure to see you. I have many, many constituents who belong to the Planetary Society and who are great admirers of yours, and certainly I admire your enthusiasm and intelligence that you bring to the fore.

I wanted to pick up on what had earlier been stated with regard to my reminiscence of the Ride report, which talked about, you know, a lunar landing. And this is something that had earlier been discussed.

I am just wondering, I notice that she is also listed as one of the advisers for the Planetary Society. Are you refuting that report's recommendation that perhaps that be preliminary to our Mars plan?

Dr. **Sagan**. Thank you. That is a very good and perceptive question, if I may say so.

Mrs. **Morella**. You may say so. [Laughter.]

Thank you.

Dr. **Sagan**. The Ride report, given the boundary conditions, the *constraints* which went into it, I think is absolutely excellent. And I am a long-time admirer of Sally Ride.

However—and the report did say that Mars is a long-term goal. It did, however, give a greater emphasis on lunar landing, lunar base than I would. But let me stress the boundary conditions laid upon Sally Ride for that report. There were two boundary conditions:

A, do not consider cooperation with any other nation, especially the Soviet Union, in your report; and B, do not consider any missions which go beyond the year 2005.

Those two considerations force the conclusion that a mission, manned mission to Mars, doesn't work because doing it with the Soviets uses Soviet technology and saves cost and so on, and forcing it before 2005 produces a kind of rush, so-called sprint mission which adds to the risk and decreases the cost effectiveness of the mission.

Had those two constraints been relaxed, which in the real world I certainly hope they would, I believe that the Ride committee would have reached the opposite conclusion about the relative weights of the Moon and Mars.

Mrs. **Morella**. So, these were constraints that were placed on the committee itself?

Dr. **Sagan**. Imposed from above.

Mrs. **Morella**. The committee itself imposed upon them the——

Dr. **Sagan**. That's right.

Mrs. **Morella**. I am also curious, do you see the need in terms of the progress that we hope to make of the need for specific legislation that perhaps you have not seen that we have introduced and/or executive orders?

Dr. **Sagan**. I think that there is a role here for a cooperative dedication between the legislative and executive branches. I think an overall goal, clearly articulated, is in a way almost independent of what it is as long as it is a long-term exploratory goal that successive Presidents can support, I think is the key necessity for the long-term health of NASA.

NASA must know where it's going, and for the longest time NASA has had no idea where it's going. And so NASA has always been trying to preserve all of the local institutions, every field center, every office, don't cut any salaries, never mind what it is that we are about. We are for the space station, NASA said, because it's the next logical step. To where? Ah, we can't tell you that.

I was on the Office of Technology Assessment of the Congress' space station committee, and we had many NASA officials come before us. And they said, look, if we had a space station, look at all these things we could do and material processing and pharmaceuticals and microgravity, physiology; you could grow plants; you could have a telescope—lots of stuff.

And then we said, yes, that's very good. If you had a space station, you could do all of that. But if you wanted to do all that, is the space station the best way to do it?

They said, ah, that's not in our area of competence.

We said, what is the long-term goal of the space station?

Well, it's that you can do all of these things.

There was never a crisp joining of the issue of what the space station was for. Why not? Because the executive office of the President had not committed itself on that subject, and I think a great deal of criticism is directed to NASA which should not be directed to NASA, it should be directed to the office of the President.

The program President sets the executive branch's policy, and the Kennedy Administration commitment to Apollo is the sort of paradigm of what it takes to get NASA really moving.

Mrs. MORELLA. I agree with you, and I think you have answered it splendidly.

Just a final point. Every once in a while when I am speaking to a group in our district, the most highly educated district in the country, et cetera, I will talk enthusiastically about the space program and where we're going, and I will have somebody who will say, "Why would you put that money into that? What about the homeless? What about what's happening here? Really, can you gauge what the rewards will be?"

Now, you commented earlier on it. You know, you said if we want to have the Russian and the United States robot shaking hands, that's one thing, or you know, what are we doing it for. All right. I can answer them in terms of the patriotic spirit and working together with other countries. I am not convinced I am doing the best job of it.

You must hear that too: where is the money going, and why there if we want more direct results.

Dr. SAGAN. I am a very strong advocate of reversing the—I have to watch my adjectives—the dreadful trend in the last eight or ten years of not caring for the homeless, of the increase in infant mortality in the United States, in the number of children below the poverty line, which will be 50 percent of the kids in America by the year 2000. That is obscene.

And lots of other important programs: The global environment, what does it take to phase out CFCs? What does it take to make us seriously address the greenhouse warming? What does it take to clean up the astonishing radioactive wastes produced in nuclear weapons plants and never told to anybody until the last year?

What about the crumbling infrastructure across the United States, the cost of which is probably in the $2 trillion range.

Add all that up and we have a very serious set of expenses. Where does that money come from? It sure doesn't come from NASA. NASA doesn't have anything like that kind of money.

So, if you look through the Federal budget and ask where is there a part of the budget which spends anything like the amount of money needed, there is only one such place—and that is the Department of Defense.

Mr. WALKER. How about HEW?

Dr. SAGAN. I beg your pardon?

Mr. WALKER. How about HEW?

Dr. SAGAN. I said that makes it easy, yes, if you want to put more people out on the streets and more kids below the poverty line——

Mr. WALKER. But how do you defend the country?

Dr. SAGAN. Well, that is defending the country also. I would propose that having more weapons is not the only way to defend the country. Having smarter kids, having healthier kids, having sewers and streets and transportation systems that work, that is part of defending the country, too.

And I think we have gone much too far toward the idea that weapons are what it takes and not nearly as far as we have to recognize what's necessary to have a self-sustaining, non-debtor nation of people who can figure out the way the world works and be competitive in the international markets.

So, that is what I would say to your constituents. It is certainly what I say when people ask me where is the money going to come from.

Now, I recognize that there is a vast national security establishment that has built itself up since the end of World War II and that wraps itself in the flag and that believes that spending $300 billion a year is absolutely essential, and $200 billion in the United States, we would be overrun by Russians.

I do not for a moment think that is the case. The fact that the previous Administration could seriously imagine a $2 trillion Star Wars program suggests that there is lots of money available for useful things.

The amount of money we are talking about, by the way, for this Mars mission, if spread out over the two or more decades we are talking about, is a few billion dollars a year. It is nothing like the amounts of money we are talking about for these other things.

I am sorry if I gave too long an answer, and I recognize it was highly political, but the question requires it.

Mrs. MORELLA. Yes, it was, but thank you very much. [Laughter.] Thank you very much.

Mr. NELSON. Mr. McMillen?

Mr. MCMILLEN. Thank you, Mr. Chairman.

On that optimistic note there, I will ask a few questions of Dr. Sagan.

I appreciate your comments, Doctor, and I am curious as to further defining some differences in the space station. You made a case that the space station is only relevant if you are going to follow through with manned exploration.

What I would be curious about is for you to define those differences from a space station maybe to an alternative like CDSF and whether, if you didn't have the space station, could you still do manned exploration?

Dr. SAGAN. I think, Congressman McMillen, the answer is no. You must have a space station to construct the interplanetary vehicles, to test out how your astronauts are going to do in long-duration space flight, to check out issues like what if there is a solar flare on the journey, how do you make sure they are protected against the radiation—storm cellars, so to say—in Earth orbit or in the transfer vehicle.

I don't see any way to do all that on the Earth. So, if you were to think that missions of humans to elsewhere was in the cards, then I think you would have to support a space station.

But a space station is not the space station. There are many different configurations, and you might have wanted to be convinced that the space station being advertised is the one that you need for this long-term objective.

Mr. McMillen. The point is that you would need some sort of space station along the lines being discussed to have further manned exploration in space? That is your bottom line?

Dr. Sagan. Along the lines that I understand NASA is now discussing, but not so much along the lines of what NASA was discussing, say, a couple of years ago.

Mr. McMillen. Would you elaborate for the record, Dr. Sagan, your thoughts on gaining that learning curve on building and operating large facilities in space and why that is essential for further exploration?

Dr. Sagan. Well, many of the things you might imagine doing—and a manned and womaned mission to Mars is only one of them—require more assets launched into space than you can put into a single nose cone of a single launch vehicle. So, you have to be able to glue—in quotes—payloads together, to weld, to bolt materials together to make bigger space stations, to make interplanetary transfer vehicles, to make habitats for wherever you're going, and all of that obviously has to be tested out in Earth orbit.

Mr. McMillen. One last question, Mr. Chairman.

How serious do you view the debris question in space with regards to the space station?

Dr. Sagan. Well, the debris question is a serious one. And if you have ever seen any of those maps that show the Earth here and a dot for every tracked piece of debris, it is black with dots. And so you have to pick the right altitude that is not dangerously full of debris and not in the Van Allen radiation belts, and there is a number of constraints for where the space station is.

I do not think that this is yet a serious issue, but there are problems that need to be addressed, including the possibility that when you have enough debris at a certain altitude, the debris starts colliding, making lots more debris and eventually you have so much of it that there is no place at that altitude where you can safely sit.

Mr. McMillen. Could there be a day when in fact the debris is such that putting any infrastructure up like the space station may be very, very risky in terms of potential contact with this debris?

Dr. Sagan. Only if we are wholly stupid.

Mr. McMillen. All right.

Thank you.

Dr. Sagan. Which is, you know, not out of the question. [Laughter.]

Mr. Nelson. Mr. Rohrabacher?

Mr. Rohrabacher. I take it from your comments that the program you are advocating would cost between $60 and $100 billion?

Dr. Sagan. $16 billion?

Mr. Rohrabacher. $60 billion to $100 billion.

Dr. Sagan. That is the range of estimates that have been made for some configuration of missions. Of course, it depends on how many people you're sending. The more people, the more expensive.

Mr. Rohrabacher. Yes. You don't think that would have an impact on education or child care or——

Dr. Sagan. Over 25 years.

Mr. Rohrabacher. Over 25 years, you don't think that would have an impact? You don't think a number of thousands of young people wouldn't have their lives affected by that amount of money being shot up into this project?

Dr. Sagan. I think it would have a positive effect on those young people. I think a nation which presents a dismal, a fearful view of the future—I mean, just look on what television prognosticates about what the future is going to be like, and it's all this bikers with automatic weapons on post-nuclear holocaust highways.

Where are the positive visions of the future? Where are the things that youngsters can say, hey, when I grow up, it's going to be really exciting, that's something I want to be part of. Maybe I'll go as well.

I think it works in that direction as well. But certainly, we have a zero-sum economy and money taken away from one thing is unavailable for another thing. I certainly recognize that. I just say that there are much better places to take the money from than NASA.

Mr. Rohrabacher. How much would it cost for the follow-up? I mean you're talking about $60 billion to $100 billion to get us up there. What comes next? What's the follow-up? What's the price of that?

Dr. Sagan. Well, Congressman, it's a little like asking Vasco de Gama, okay, now you've made it to India, now how much is it going to cost to do whatever follow-ups you're going to do. I don't know that Vasco de Gama could have made that estimate, among other things because he could not have possibly imagined what was going to come next.

Mr. Rohrabacher. I think that if you will read history, that you will find that the debates over whether that particular mission should have been financed, that there was lots of indication as to actually how many resources would be returned for the amount of money put into that exploratory mission.

Dr. Sagan. There was lots of opposition to it as well.

Mr. Rohrabacher. I'm sure.

Dr. Sagan. And what it took was Prince Henry, the Navigator—that is, the head of state—to make a commitment to it.

Mr. Rohrabacher. He wasn't convinced, was he, that the reason that they were going there was to create an illusion of better relations with some other country?

Dr. Sagan. Well, neither was I talking about an illusion of better relations. I was talking about the reality of better relations.

Mr. Rohrabacher. Image of better relations.

Dr. Sagan. But as I tried to say at the beginning of my testimony, while the Apollo program was certainly in the context of confrontation between the United States and the Soviet Union in space, there seems to be no reasonable utility for the continuation of that. Both nations have fully demonstrated their ability to annihilate the other.

So, if there is going to be some kind of relationship between the United States and the Soviet Union in space and it's not going to be competitive, I think that leaves cooperation as the only alternative.

Mr. ROHRABACHER. If the United States would involve itself in this type of a project with the Soviet Union, of course, we would be further encouraging the Soviet Union to commit its resources towards this end and maybe there would be fewer resources because we would be working together.

But do you actually believe that a country like the Soviet Union, which is so poor that it currently reuses needles to the point that they are actually transmitting AIDS among different patients in the Soviet Union, that a country that poor should be pouring that amount of its resources into space exploration?

Dr. SAGAN. Well, I point out that in the United States we also use the same needles, and we also spread AIDS in that way, and we have a lot larger population of needle- using AIDS patients in this country than they. And it's among poor people.

Mr. ROHRABACHER. Do you think that is a fair analysis, Doctor?

Dr. SAGAN. Sure.

Mr. NELSON. The Chair asks that we please suspend.

Now, the Chair has been enormously patient with all of this, and I am going to have to rein us back on track. We are going to get away from the political discussions. We are going to get away from discussions about needles in the Soviet Union, and we are going to get back onto the subject at hand, which is the space station.

Now, I could have worn you all down by the chairman exercising his prerogative by asking all the questions in the beginning, and I did not. For the benefit of our members, I turned it over to you. I have put no time limit on anybody, and I want everybody to have at it. But we are going to have at it on the subject of the committee.

Mr. ROHRABACHER. Could I make one note——

Mr. NELSON [continuing]. Jurisdiction. And I am not picking on you, Mr. Rohrabacher. It happened down here and so forth. And you just hush, Mr. Nagle. [Laughter.]

Mr. NAGLE. If I could——

Mr. NELSON. When we want to uncage you, we will do so, Mr. Nagle. [Laughter.]

Mr. Rohrabacher?

Mr. NAGLE. I want the record to show this wasn't my fault. You can do it without me. [Laughter.]

Mr. ROHRABACHER. With the Chair's permission, I would like to add just one thought or one moment of thought.

Mr. NELSON. Certainly.

Mr. ROHRABACHER. That when we are talking about cooperation with the Soviet Union and we use as an example the Soyuz mission, for example, which has been spoken about, you know, it was a mission that took place in the mid-1970s, it was a time of the greatest peacetime military expansion of any power in the history of the world. It was going on in the Soviet Union at the time.

And at that same time we saw incredible abuses of human rights in the Soviet Union and today a lot of the things that Gorbachev is complaining about, a lot of the changes you are applauding right now were just—the fact is that Gorbachev is complaining about the things that were happening when we were in direct cooperation with the Soviets in space.

Cooperation, you know, with an adversary, especially an adversary that has a totalitarian philosophy at the basis of its regime, does not necessarily lead to a more peaceful world. That is just my philosophy, and I respect your right to have your philosophy in this thing, and that's all I have to say.

Mr. NELSON. Do you have any further questions, Mr. Rohrabacher?

Mr. ROHRABACHER. Okay. You mentioned——

Mr. NELSON. With regard to the subject of the jurisdiction of the committee. [Laughter.]

Mr. ROHRABACHER. All right.

You were talking about robotics, and I was very interested in your position that if it is just for science, that we should send robotics. Now, that is a very—I mean, I was just sort of rolled over by that observation. Could you expand on that for us?

Dr. SAGAN. The cost of a manned mission compared to a robotic mission to some other world for some comparable purpose is about—tends to maybe 100-to-1. So, the cost of sending people, because of the obvious safety considerations, is very high.

Artificial intelligence is proceeding apace, although it has not been given the attention in NASA that it deserves. I chaired about ten years ago a NASA headquarters committee looking into artificial intelligence and robotics, and our conclusion was that despite NASA's image of being at the cutting edge of technology, it was 10 to 20 years behind the state-of-the-art in artificial intelligence and robotics.

NASA has still not filled that gap, but it has at least addressed the issue. Were we to be further along in that you could have much more capable machines in space.

Let me give you a specific example, Congressman. When the Skylab sunshade got stuck, an astronaut went out with a wrench and freed it. And that was widely advertised as a reason why you need people up there, otherwise this whole part of the mission would have failed.

But it was very clear that if we had spent $2 billion on multipurpose wrench-wielding robots in Earth orbit, that we could have had a robot—perhaps under control, a teleoperator under control of the humans on Earth—that could have done that and a great deal more.

So, sometimes the comparisons between humans and robots are biased in favor of humans. It's not hard to understand. Those making the comparisons are always humans. [Laughter.]

Dr. SAGAN. What we have to do, though, is to compare what a machine that had cost the same as the comparable human presence in space would be able to do.

And when I make that comparison, I find that robotics are vastly underused in Earth orbit. And it's the kind of robotics that I alluded to a moment ago but which has not been adequately developed, and that is, you are the NASA operator sitting on Earth, you have a kind of head gear on, and you are connected to a set of cameras and a set of mechanical arms up in Earth orbit.

You turn to your left, the video cameras in Earth orbit turn to their left, and you see this new scene. You put out your arm, the mechanical arm goes out. You turn your wrist to the left, the mechanical arm's wrist turns to the left.

And because the light travel time is so quick, it's virtually instantaneous for you in low Earth orbit.

So, you in a certain sense can be up there controlling instruments of great power, constructing things, observing things.

Mr. ROHRABACHER. And that is your recommendation in terms of getting the greatest—I hate to use the words "bang for the buck" with you. [Laughter.]

But to get the greatest utilization of each dollar that we spend in space, that we should focus more of our attention in terms of scientific achievement on robotics rather than on concentrating on putting men into space?

Dr. SAGAN. And women. Yes. And even for the construction of a space station, where you imagine there would be people up there, nevertheless robotics and teleoperators of the sort I just described can be extremely effective in constructing human habitats in Earth orbit. It could be done more cheaply, and it could be done much more safely. You would not be risking the lives of the girder operators.

Mr. ROHRABACHER. Okay. Thank you.

Thank you.

Mr. NELSON. Okay.

Before I call on Mr. Johnston, let's start to tighten our answers and tighten our questions. Time is slipping on here.

Dr. SAGAN. Good.

Mr. JOHNSTON. Mr. Sagan, a very tight question. I am confused as to if you were director of NASA, would you go for manned or unmanned space flight?

Dr. SAGAN. If I were the administrator of NASA, I would make every effort to convince the President of the United States that it was important to have a commitment, a national commitment, on long-term international exploration of space with the Soviet Union and other nations. And if I succeeded in convincing him, I would then make every step necessary to guarantee the effectiveness and safety of humans in space.

Mr. JOHNSTON. Then your priority with another country would be manned space flight?

Dr. SAGAN. Well, because it's the big-ticket item, I guess, in terms of dollars, it would have to be.

Mr. JOHNSTON. Yes. Thank you.

Mr. NELSON. Mr. Walker?

Mr. WALKER. Thank you, Mr. Chairman.

Could you give me some idea as to what you think an appropriate level of funding for NASA would be in this year's budget?

Dr. SAGAN. Well, NASA certainly is still coming off the Challenger catastrophe and coming out of this self-inflicted or—anyway, executive branch-inflicted drought in robotic exploration of the solar system, the 11-year period in which we haven't launched a thing. So, that requires an increase in funding, and there is something like a 20 percent increase in the NASA budget, if I am not mistaken, this fiscal year over last. And that sounds somewhere in the right range.

I do not think that any of the things that we have been talking about involves a greater commitment than the Apollo budget.

Mr. WALKER. Well, what I want to get is, if we were to design a visionary budget, whether it's the executive branch that is at fault or Congress at fault, if we were going to design a visionary budget, what is the real level that NASA should be at in order to pursue real visionary activity, in your opinion? We are talking about a $13 billion budget this year.

Dr. SAGAN. Right.

Mr. WALKER. What would you regard as an adequate budget to be truly visionary?

Dr. SAGAN. A truly visionary budget would be an increment above that. You could probably do it for $15 billion. You might even be able to do it for $13 billion, but I think $15 billion would certainly do it because we are talking about a long-term buildup toward the——

Mr. WALKER. So, you are willing to settle for one-third of what we were spending in the '60s?

Dr. SAGAN. No. You said what was necessary for a visionary budget.

Mr. WALKER. That's right.

Dr. SAGAN. And I have given you the minimum that would be necessary for a visionary budget, in my view.

Mr. WALKER. But I mean that is—the figure you just gave me—is one-third of what this Nation committed in terms of its Federal budget.

Dr. SAGAN. That's about right.

Mr. WALKER [continuing]. And its national resources in the mid-1960s.

Dr. SAGAN. That's right but——

Mr. WALKER. We were spending 3.6 percent of the Federal budget in 1966 for space activities. Now that would be the equivalent of spending $40 billion a year in space activities out of the Federal budget for civilian space right now. It would mean that we were spending approximately three percent of our gross national product at that time. That would be the equivalent of spending something on the order of $120 billion in space activities as a whole in the present time.

You know, we are nowhere close to any of those figures at the present time.

Dr. SAGAN. Yes.

Mr. WALKER. What I am suggesting to you is if you are really going to talk about visionary programs, why don't we talk about visionary programs that are at least at the level of what we were willing to do 20 years ago?

Dr. SAGAN. Yes. Now that I understand the difference in what we're saying, I think I see the answer.

The answer is that in 1961, when President Kennedy announced the Apollo program, it was by the end of the decade that he wanted to put an American on the moon and bring him safely back. That was an extremely tight schedule. It took eight years. And as I said before in response to some other member's question, that technological leap is, I think, much greater than what we are talking about from now to Mars. That leap from '61 to '69. So, of course, it was more expensive.

Mr. WALKER. But why is vision only Mars? I mean the fact is that there is a whole universe out there that could be done with robotics. You know, you could have an expanded space science program. I think we make a mistake to focus only on Mars as the only vision that NASA ought to have, or that this country ought to have.

I mean, you know, we can do far more on the moon in terms of producing products that might be useful to human kind than we can on Mars, and we can be back at the moon by the turn of the century if we were really visionary. You can build transportation systems such as a national aerospace plane that offer all kinds of potential both in terms of low Earth orbit and Earth capabilities if we are willing to be truly visionary and willing to really focus on the nature of the future.

What I am disappointed by is, you know, I don't hear you say anything beyond, well, we ought to go over and join up with the Soviet Union and go to Mars and that's vision. That isn't vision.

You know, it seems to me that human destiny and so on is far more expansive than one mission. That was the problem with Apollo. Wouldn't you agree that it became a one-mission kind of thing? Kennedy outlined a technological leap, by golly, we did it, and then we quit, and we went on to the next mission, which happened to space shuttle and so on. And once we got that mission done, now we come up with another mission, the space station.

Missions are not vision. And it seems to me that if you want to talk really visionary policy, you better talk about having the resources in order to really pursue the vision.

Dr. SAGAN. I actually agree with almost everything you just said. And let me try to explicate the apparent differences. I don't think there is a serious difference.

Mr. NELSON. With brevity. [Laughter.]

Dr. SAGAN. With brevity. That's not too easy, but I will try.

First of all, on the point that Apollo was a stunt, we did it and then it ended.

Mr. WALKER. No, it's a mission, not a stunt. But it was one mission.

Dr. SAGAN. Absolutely, because its objective was not exploratory. Its objective was not about human habitation on the moon. Its objective was to show that we had the rocket power to do it. And so when we showed we could do it, that was the end of it. That is just my complaint. We are in agreement on that.

That is not the case for Mars. Mars is not to show you can do it and you're done. Mars, as I said, has a surface area equal to the land area of the Earth. It will occupy us for centuries. So, that is one point.

Secondly, on Mars only, by no means am I advocating Mars only. The chairman, in his introductory request to me, asked me about that, and so that is the reason that I am focusing on it.

I have come—I don't know if there is time—but I came prepared to talk about the importance of the CRAF/Cassini mission to the outer solar system, which I believe will be before you, absolutely essential to understanding the origin of life, a new plateau in planetary exploration.

Mission to Planet Earth so that we can understand the Earth as a global system at a time when there are very ominous signs of global climatic change and change in the ozonosphere, these are not just visionary but, I think, things that are essential for the health of the nation and the world.

There are a large number of other such things which I think NASA ought to do, and many of them are small change compared to the cost of putting people up. Neither of the things I just said involve humans at all.

So, for that reason, as I said to Mr. McMillen, the manned space flight is the big-ticket item and so it tends to focus the discussion. But I think there are many very cost-effective, visionary things that can be done with robotics. And I have always been for them.

Mr. **Walker**. But I guess what I am saying to you is that as you carry the message, don't get locked in, as far as I am concerned, to status quo, to what is, and suggest that somehow we could get by with $18 billion a year to do all the things we want to do, or $15 billion or whatever it is.

I mean it seems to me that at the very least that visionaries ought to be willing to suggest that we should do as much in 1989 as we were willing to do in 1966 and that anything less than that as a national commitment is worthless.

And it doesn't just lay at the door of the executive branch, it lays at the door of this place too because we have gone along with those budgets. We can reorder budgets if we want to around here. It lays right at the door of people who sit in these committees and so on and make decisions and make decisions about budget and appropriations and authorizations. And we are never going to move beyond the status quo kind of mentality as long as there is on pressure from the outside to do it.

You have great credibility with many people out there. You ought to be saying that the American public, if they really want to do the things that you're talking about, have to be willing to come up with something on the level of about $40 billion a year in civilian space, because that is what we were willing to do in 1966 and we haven't been willing to do it since.

I thank you for your time.

Dr. **Sagan**. I thank you, too, Mr. Walker. And I must say I am stunned. I am not offended. I feel great. But I am stunned, if I understood. That is the Republican side and that is the Democratic side. [Laughter.]

So, may your tribe increase. [Laughter.]

Mr. **Nelson**. Let me say that with every erg of energy in my body, I try to keep this subcommittee from being "that's the Republican side and that's the Democratic side," and bring it together.

Now, Mr. Buechner, Mr. Lewis, you all are next, and I would urge brevity in your questions so that we can move on.

Mr. **Buechner**. Thank you, Mr. Chairman.

Doctor, thank you very much. Although when you said that you agree with almost everything Bob said, I think he probably won't sleep well tonight. [Laughter.]

I would like to go back to a couple of things you said, and I will try to make them as brief as possible.

You mentioned about the vision, and I happen to agree with you that we have lost the vision and the vision was, I guess, when the Challenger went down, we had gotten to the point where people had begun to think that the Challenger was actually like a 767.

I mean, we were taking schoolteachers and ordinary people—in parentheses—and it was just another flight. And then when it went down, we said, oh, there's something wrong, gee, maybe we shouldn't be in this. And I think slowly but surely we have gotten back to it. And whether it's the Voyage to Planet Earth or it's the interplanetary exploration, I think we have tried to at least retool that idea.

What bothers me, though, is that if we are trying to find a vehicle that generates that type of enthusiasm, that type of vision so that we can take the young people's minds away from Luke Skywalker and put it into Sally Ride, I guess maybe what I want to talk about is robotics, for all of its technical achievements, does take the human element out of space exploration.

As a scientist but a scientist who really understands communication, do you see an inherent weakness then in the stimulation, if all we are sending up are vehicles with gadgets, even though from a scientist's perspective you may be able to bring back—and obviously more safely—those bags, do we still have a problem in the stimuli part of it?

Dr. **Sagan**. Yes, and that's why I say if we are only interested in science, then we send robots, but if we have a broader scale of objectives which I call social or political or historical, then it may very well be necessary to send people. And in my view of the importance of international cooperation in space, doing stuff which makes things better down here, you have to send people. So, I entirely agree with that.

Mr. **Buechner**. Well, in that vein, though, as you were describing Mars versus the Moon—you talked about the Moon being just this dry old place—one of my constituents is the head of the Department of Earth and Planetary Sciences at Washington University in St. Louis. I don't know if you are familiar with Dr. Haskin.

But I wrote him basically about what you had to say, and he responded that some argue that the Moon is an exceedingly dry desert and that we will have to go to other bodies, i.e., Mars, Phobos, and the Earth asteroids, to obtain volatile elements such as hydrogen, nitrogen, carbon even for use on the Moon.

This is nonsense. Consider hydrogen in just the outer two meters of its soil, the Moon contains enough of that element from the solar wind to supply all the hydrogen conceivably needed for rocket fuel for a thousand years. Converted to water, this hydrogen could form a lake—and he gives the dimensions.

I am wondering if we don't get caught up in a way with the sizzle of going to Mars. I mean it is the Red Planet, the Forbidden Planet of H.G. Wells, and the Moon then becomes just sort of this old hunk floating around up there. You know, once again from the scientist's standpoint now and taking you away from the communicator, do you think that maybe you and some of us are maybe downplaying the usefulness of the Moon as the first place to send a manned long-term mission?

Dr. **Sagan**. Okay.

Mr. **Buechner**. That is my last question, Mr. Chairman.

Dr. **Sagan**. If we are talking about constructing vast engineering artifacts in Earth orbit or on the Moon, then of course we would want to use materials that are already up in space. If we'd have to carry them up the Earth's gravity, well, much more expensive.

So, what Dr. Haskin's answer presupposes is a commitment far beyond anything that I talked about earlier; namely, vast engineering constructs in Earth orbit or on the Moon. If there were a national commitment to that, then it would necessarily involve using lunar or possibly asteroidal materials.

But failing that, I don't see the need for those resources because we are talking about tiny amounts of matter needed to construct the interplanetary spacecraft and so on. You'd not have to get that from the Moon.

If Mars were in orbit around the Earth, I think that there would be no contest about which is more interesting. There's no question that there is some science you can do from the Moon and there is some astronomy you can do from the Moon.

But as far as the scientific excitement and the excitement of an everyday person, Mars wins hands down. And it has volcanos three times the height of Mount Everest. It has dust storms. It has intricate polar terrain in which we think we can see the past history of Mars, each layer laid down in a different epoch, ancient river valleys. It has a range of geological features and a climate and a dynamism that the Moon just doesn't have.

The number of scientific issues that can be addressed on the Moon is very small compared to those on Mars. There is no climatology on the Moon. There is no oceanography on the Moon. There is no biology on the Moon. There is no organic chemistry on the Moon.

All of those are thriving topics in the study of Mars, and that is the only reason I did those comparisons.

Finally, as far as the public is concerned, I find a lot of people say to me we have been to the Moon, we brought back some rocks, they look just like the rocks in my Grandma Tillie's back yard. How did that justify $25 billion? And then I go into a story that I have already gone into here.

I find public enthusiasm for the Moon extremely muted and for Mars very dynamic.

Mr. **Buechner**. Thank you, Doctor.

Thank you, Mr. Chairman.

Mr. **Nelson**. Speaking of the Moon, is there a full Moon out in the sky? [Laughter.]

Mr. **Buechner**. Is that why we are not in session? [Laughter.]

Mr. **Nelson**. I thought it might be some of the reason for the excessive loquaciousness of the committee.

Mr. Lewis?

Mr. **Lewis**. No questions, Mr. Chairman.

Mr. **Nelson**. Any further questions from the committee or the staff?

[No response.]

Let me ask you about—oh, let's see, here it is. We had a hearing on February 9 on transition studies, and Dr. McLucas and Mr. Logsdon to testify. And they testify about international solar system exploration working groups.

Do you have any comments about those?

Dr. **Sagan**. I think part of what Drs. Logsdon and McLucas testified about was a conference that was held here in Washington December 8 to 10 of last year called Developing the International Agenda for Space Exploration, and that was a meeting that was cosponsored by the Planetary Society. And I thought the conclusions that came out of that meeting and presented in their testimony before your committee are ones that I strongly endorse.

There was a very high-level set of American scientists and policymakers, representatives from Canada, France, Germany, and the European Space Agency that had a very mutually consistent view on the importance, each for their own Nation, but the Americans for the United States, of international cooperation—not just in grand missions like going to Mars but in other missions, especially ones on which we found ourselves in resounding mutual agreement on, and that is the so-called Mission to Planet Earth, which was just a matter of simple planetary hygiene.

We have to understand what we are doing to this planet, and that is very different from the exploratory agendas. It should not be thought of as an alternative to exploration, it is one of those things like weather satellites or military reconnaissance satellites that are obviously beneficial and that ought to be done by spacecraft.

So, I am sure that while I have not seen their testimony, that I am in agreement with what they testified.

Mr. **Nelson**. Excuse me one second.

[Pause.]

You had asked NASA for their—I guess it might have been on behalf of the Planetary Society—that you asked them a question on modifying the space agreement. Do we exchange studies or do we actually get into the working groups and modify what is there now?

Dr. **Sagan**. Well, it's better than it was a few years ago, but it's still pretty pathetic. On robotic exploration of Mars, what we now do is each nation does its own study about how to perform that. And then these unclassified, open-literature, widely distributed summaries and reports are exchanged. They would be exchanged even without the agreement.

That is the extent of joint cooperation that we have right now—well, there is a few other things. There is a handful of American scientists working on Soviet planetary missions. There will be for Magellan to Venus a handful of Soviet scientists working on American missions.

There certainly is a more constructive atmosphere in NASA now than there was a few years ago about considering the prospect for international cooperation, but it certainly has a long way to go.

And this is, you know, in contrast to a very large range of American opinion. Newspaper editorials, including ten in the New York Times, calling for U.S.-Soviet cooperation in Mars exploration, opinion polls, the Planetary Society's Mars Declaration signed by an amazingly ecumenical group of distinguished Americans. The Republican Party's own statement in its platform saying that manned exploration of Mars should be high on the agenda. Statements by Democratic presidential candidates. Many bills brought before the Congress. All of which indicate a trend in that direction, except that the executive branch is running a little slowly behind the rest of the world.

Mr. NELSON. Did you proffer a question either individually or on behalf of the Planetary Society to NASA as to their opinions on this subject on the working groups?

Dr. SAGAN. What you are perhaps referring to as a——

Mr. NELSON. The U.S.-Soviet agreement.

Dr. SAGAN. As a product of that meeting, December 8–10 in Washington, I did send a letter signed by a few colleagues to the NASA administrator, urging that the space cooperation agreement be broadened, that the degree of international cooperation be made wider, and a few other things, including Mission to Planet Earth and so on.

And the answer that came back from the perhaps deputy administrator for international relations, something like that, on behalf of Dr. Fletcher, was that Mission to Planet Earth was terrific but that they don't want to be sped up in international cooperation with the Soviets.

Mr. NELSON. What is your personal opinion about whether or not it's time to amend the U.S.-Soviet space cooperative agreement to allow for cooperative studies for manned exploration?

Dr. SAGAN. My opinion is it's time. And notice, there is a lot of things that could be done before that. We could be jointly planning robotic exploration of Mars. We could be jointly planning studies of the Earth from Earth orbit. The Soviets live on this planet just like us. They also pour carbon dioxide and chlorofluorocarbons and methane and nitrous oxide and other pollutants into the atmosphere.

What they do affects us, what we do affects them. It is clearly in our mutual interest to cooperate in understanding the Earth.

I think it's time to amend those agreements, to broaden them, and perhaps the climate in the present Administration is more favorable than it used to be.

Mr. NELSON. Any other comments by the committee?

[No response.]

I might say, Dr. Sagan, that you have been stimulating, and you have been well received with a great deal of interest on the part of this committee. And we appreciate your comments.

It was two days ago that I decided to ratchet up some focusing of attention on the issue about the lack of long-range goals, the vision that Bob Walker was talking about, for the U.S. space program. And I am going to give, from time to time, some pronouncements about this and hope that it sort of infiltrates the system and at least stimulates people to think beyond the next project.

Be the project the space telescope or be it the space station, those are projects, they are not the goal, they are not the vision.

And what I tried to articulate as I did in that previously published work was to say that we ought to really try to energize America by lifting ourselves above and going out and challenging ourselves as we did in the '60s, what was thought to be a real challenge. It wasn't thought to be impossible to go to the moon, but nobody had ever done it, and we really needed to stretch ourselves to do that.

And I think, and I also pointed out in the speech, that this committee can't do it. As much as we would like to lead the space program in this committee, we can't do it. There is only one person who can, and that is the President; and that the President—and this President who has stepped in with such a large amount of goodwill toward the space program, with some fairly substantive statements about it and with some advisers that, hopefully, will advise him appropriately, that he has a rare opportunity then to set a goal.

My preference is that that goal be an international human mission to Mars. And I think that that would do a number of things, and I just want to quote two sentences from the speech that I made:

> If we focus on a goal that encompasses all of our space efforts, we will gain a sense of direction we have lacked for decades. With a vision to guide us, the setbacks that inevitably will happen as we move ahead will be less taxing on our national psyche. We will know what lies beyond the setback because we have that goal, that vision we are trying to achieve.

So, for the participation of you today, for the participation of the members, I think it has been most stimulating, and I appreciate your participation.

Dr. SAGAN. Thank you, Congressman Nelson.

I would also like to thank all the members of the committee for giving me an opportunity to answer such a wide variety of questions, and I found it a most stimulating afternoon as well.

Mr. NELSON. Thank you.

May I call up Dr. Martin.

[Pause.]

Mr. Walker, as they are setting up here, you and I have been on a lot of this together over the last four years, and you know into the give-and-take of a hearing like this, I think in part this hearing has reminded us all of why we are on this committee, why we continue to fight for the NASA budget for, in other words, a civilian space program for this country.

I think it has reminded us also of why we sometimes have become frustrated with those who cannot share in the vision that we have. And so I am happy about the progress of this hearing.

Dr. Martin?

STATEMENT OF DR. FRANKLIN D. MARTIN, ASSISTANT ADMINISTRATOR, OFFICE OF EXPLORATION NATIONAL AERONAUTICS AND SPACE ADMINISTRATION ACCOMPANIED BY DOUGLAS A. O'HANDLEY, DEPUTY ADMINISTRATOR FOR OFFICE OF EXPLORATION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. **Martin**. It is a pleasure to be with you this afternoon. I have a copy here of our written testimony. We would like to submit that for the record.

But if we could, I would like to show you a few pictures and discuss a few things with you. I want to share with the committee the accomplishments this past year of the exploration office under the leadership of John Aaron, my predecessor

I want to give you a view of what is important about the current NASA budget. Mr. Walker asked about what should we be investing in. I want you to understand how important that precious $13.3 billion is to the future of the Nation. I have some views on that.

I would like for you to understand what we are doing this next year and where we're going and how we're beginning to focus down within the Office of Exploration on reasonable alternatives this Nation could consider doing either alone or in conjunction with other Nations, and we can discuss that.

I think the comments of Carl Sagan here will help, I think, the things I have prepared to discuss with you, will probably help somewhat in making that a bit clearer and will build on his comments.

So, I think a lot of the discussion you have had may not be as necessary, and so we may be able to make up a little time with you. So, I would like to indulge you a bit with a few pictures, and I would like to stand, if I could. We will try to work this with the microphones.

I would like to remind—let me move over here—this business of manned space flight is a very personal thing for me. You see, I was a senior in high school when John Kennedy committed this Nation to put a man on the moon and return him within a decade.

So, I have seen the benefit of the vision, and I have seen the difficulties of having a vision that may be too limited when we talk about missions or long-term visions.

You see, I graduated with a Ph.D. in physics from the University of Tennessee in 1971, and I believe if you check the records, that was the year that this Nation graduated the most Ph.D.s before or since.

If you look now in the schools, you will find out that most of the graduate students we have are foreign nationals, not U.S. citizens. And I think all you have to do is look at the history of what has happened since Apollo to sort of see why we are in this situation that we are in right now.

Investing in science and technology is an investment of the future of the Nation. It's up to the leaders of the Nation to decide just how much that is.

Another lesson from Apollo is that my very first job in 1971 was to work on Apollo mission planning, orbital science, some of the same kinds of things that are being done on the Mars geochemical orbiter, but at lunar orbit. And the reason that I got the job over someone else was that NASA couldn't hire. We were coming off of the Apollo program; it was the last couple of missions. And I was the low-bid contractor who got in the program because he couldn't get a job doing what he wanted to do—another lesson.

And I think I am standing before you here today to talk about the future that this Nation probably could have had if we had kept that commitment of the budget at the four percent or 3.6 percent or five percent. I have heard all those numbers.

But we would be talking about celebrating the return of people from Mars, not how do we get them there. And we wouldn't be discussing about whether we would have a lunar base or not, we would have had one and we would have had a space station.

So, I find this whole thing personally rather touching. And it is good news that I am here, and I think there is a little bad news in it, but I am excited as hell about it, and I intend to share that with you.

So, first of all, I am going to use some posters. And I apologize to the folks behind us here.

[Slide.]

This past year the office of exploration looked at four case studies. And I think it's important to understand that these are case studies. They are not necessarily missions that we would be prepared to commit to. I would like to take you through each one of them.

One is what we would call a sprint mission to Phobos, the satellite of Mars.

Now, we could go to Phobos in a rather inexpensive way in terms of mass and low-Earth-orbit to get there, because you don't have to go down in to the gravitational field of Mars. You don't have to pay the price of landing on Mars in terms of mass and getting off the planet. The gravitational field on Phobos is about a 1000th of what it is here in this room. So, it is a relatively easy place to get to.

The only problem with Phobos is that unless you are going to Phobos to go somewhere else, it's a little limited. There are some scientists who get excited about it. Of course, the Soviets have a satellite there now.

There are some people who believe there may be water and things like this and we maybe able to mine it for propellant.

But to me, going to Phobos without a commitment to go on to Mars is a little like taking your kids to Orlando and not taking them to Disney World. Mars is Disney World. Phobos may be a step on the way. We need to analyze that and make sure we understand what's going on.

Next chart, please.

[Slide.]

We also looked at what we call a sprint-class mission to Mars, an Apollo-class mission, put humans on Mars and return them safely within some finite period of time.

And this is a rather dramatic picture from the report of astronauts, cosmonauts, you pick them and name them, but astronauts exploring the surface of Mars and actually looking for fossils and things of that sort. A lot of mass in low Earth orbit is required to do that mission—millions and millions of pounds.

Oh, I stole one of your lines there. [Laughter.]

Millions and millions of pounds. And that gets into the requirements, the transportation requirement, to get those pounds up into low Earth orbit.

Next chart, please.

[Slide.]

There are those who would like to go to the moon, and one of the test cases that we used, the case studies, was to actually see if we couldn't possibly put a man-tended astronomy base on the far side of the moon. The far side of the moon protects the radio telescopes from the noise from the Earth's radios. And so it's an excellent place to do radioastronomy and other kinds of astronomy.

My feeling about that particular mission is I don't think you would go for just astronomy reasons alone. I was involved in the development of what is now called the Great Observatories. These would at least be called the Grand Observatories. And I think if we went to the moon, we would want to do it for a broader set of objectives.

Next chart.

[Slide.]

Which brings us to using the moon as a steppingstone to go other places in the solar system. And in this case, one of the things we look at is the possibility of mining the moon. Mining the moon in the context of using lunar materials, as was described earlier, to produce the propellant that we might need in order to fuel up a rocket in lunar orbit and send them off to Mars. That could potentially save a lot of mass in low Earth orbit in order to get there and, consequently, a lot of transportation. That is yet to be proved. That is part of the system trade studies that we are doing right now. Of course, this would lead on to Mars in the long term.

There are other considerations of actually mining the moon and returning things like helium-3 that could possibly be used in fusion reactors downstream at some time, assuming we could develop fusion reactors and figure out how to mine the moon efficiently. That is no trivial task, and obviously would be a major investment.

But learning to live off the land is an important thing, both in terms of system trades and how to get there efficiently, but in the long term, if the vision really is beyond just the mission, then someday the people in this room and the people in this country and the people in this world believe that human beings are actually going to live and work on the moon and on Mars, that there will be human settlements there, then learning to live off the land is absolutely essential.

So, we are beginning to try to understand ways, evolutionary ways, that we could actually develop devices that use nuclear power on the surface of these planets, a lot of nuclear power, to basically eat rocks and sand and produce oxygen and other materials that could be used productively.

So, that is a part of our program in the long term.

Next chart, please.

[Slide.]

Which brings me to today's budget. And this chart, I believe, John Aaron may have brought before this committee in the past.

But I will lead you around the chart. There is a copy of it in front of you. I don't expect you to try to read the words that are there.

The lesson that is learned from this particular year's case study is that we need five things in order to be able to talk seriously about leaving the planet and going somewhere else.

We will start in the lower right-hand corner. We have to have heavy-lift transportation. Millions of pounds in low Earth orbit means something beyond the shuttle. It means at minimum something like the advanced launch system, shuttle C-class vehicle that can put up 200,000 pounds in low Earth orbit.

It is my personal opinion that because of the large number of mass—large amount of mass that we need in orbit and the amount of integration test and checkout—it's not just putting it together, as you know, sir, putting it together and making sure the total system works takes time. And the bigger pieces we can test out on the ground and integrate in orbit the better off we are going to be because we can't move Cape Kennedy up into orbit. The number of humans that are required to do that job may just overwhelm us. And so, heavy-lift transportation and we are going to be looking in the long term of evolutionary-class vehicles that might be able to put up 250,000 to 500,000 pounds. When you start talking about half a million pounds, you're talking about leaving the planet. We may be able to go somewhere.

So, the money that is in manned space flight budget for advanced studies in transportation—evolutionary versions of the shuttle, what's going on with the Department of Defense in advanced launch systems—is absolutely essential to being able to seriously talk about these things. Many of those are studies under way.

If you go up a little bit further, you see unmanned precursor missions. Now, Carl Sagan spoke very eloquently about the Mars rover sample return and the fact that we are actually doing parallel studies with the Soviets, looking at ways of possibly doing that.

I look beyond that downstream in terms of robots actually assisting human beings. We have a flight telerobotic servicer on the space station. I don't happen to believe that that is necessary to assemble the station. Humans can still do that faster than robots. But having those robots or that robot outside to assist humans in emergency situations and do work so that they don't have to don spacesuits and go out in that particular environment, I think is a wise thing. And I think when we have humans on the moon and Mars, I think robots and rovers will be companions and assistants to them just as we use robots to help us get our job done here today. So, investing in that kind of thing is an important activity.

If you move on further, you see Pathfinder. And I think this committee is very familiar with Pathfinder. The whole Pathfinder advanced technology budget, we have got a modest start this year. If that budget doesn't increase over the next couple of years to the $200 million a year level, I don't think we can seriously consider moving off beyond space station. We certainly can't consider going to Mars. And the lunar decision may be possible, but I think there is a certain element of risk in that.

So, Pathfinder is absolutely a key to the future in terms of humans in space and the technology, whether it's aerobraking that we need in order to enter the orbit of Mars and come back to the Earth or whether it's the ability to move cryogenics from one tank to the other in orbit, the ability to assemble large things in orbit, the list goes on. It is absolutely enabling to this capability.

Mr. **Nelson**. What was that? $200 million a year?

Dr. **Martin**. Yes, sir. I think it has to get up to around that level on an annual basis and a continuing way, or we are going to really be severely constrained.

That is not to say that getting started right now, I recognize the budget constraints and it was tough for NASA to get the $13.3 billion. The country has a deficit problem. But that is an important area to invest in.

If you come down a little bit further, life sciences research, both on the shuttle and on the space station, become absolutely enabling. And I would like to—I will come back to the space station in just a minute. In fact, I think what I would like to do is go to the next chart.

[Slide.]

I think the key issue here is not that the space station can't do the research that we want to have done or that that research is in and of itself incompatible with materials sciences research. It needs to be funded. We need to put some money into it. We need to get some flights going. There is plenty of volume on space station that will allow us to accommodate the life sciences research that we need to do, and the materials sciences research.

I am not talking about manufacturing, I am talking about a serious new scientific discipline that deserves consideration just as much as any of the other science disciplines that we support; materials sciences research that is going to be done on space station, not just by this Nation but also by our partners, the Japanese and the Europeans and the Canadians that are also going to be conducting that kind of research on the station.

There is plenty of volume on that station to satisfy the requirements that I think we need to have satisfied in order to go to Mars. And I think we need to get beyond the debate about all the conflicts and get on about deciding how we're going to do that job. And that's Len Fisk's and Jim Odum's job to do that, and I intend to support them.

There is a question, though, of life support, and the fact that humans do have a problem in low gravity. And we are not prepared to just sit back and hope that countermeasures might solve the problem someday. We actually have an engineering trade study going on this year which will tell us the answers to some simple questions: Can we build a 1G, one-atmosphere spacecraft that we could use to go to Mars?

[Slide]

Now, that is a tether device. This is one version that you see here. If that rotates at about two revolutions per minute, which the doctors tell us might be okay, then that tether is about a quarter of a mile long. If that thing rotates at about one revolution per minute, that tether becomes on the order of about a mile long.

Now, we've got to get some good engineering questions to that, and we are going to study that to see if that can be used as a backup to a possible countermeasures low-G type spacecraft to go to Mars.

If indeed that proves to be a useful thing, then that also opens up the possibility that we may not have to take sprint-type missions in order to get there, in order to shorten the time so that people aren't exposed to low-gravitational fields for a long time. We may actually be able to take a more leisurely course, at least in terms of the gravitational effects. And that again translates into trade-offs in mass in low Earth orbit in transportation required to do the job.

Let's go to the next chart.

[Slide.]

Space station. In fact, the last time I came before this committee, I believe I was with Mr. Stofan, discussing the space station program. It happens to be something I know a great deal about.

And in addition to the scientific research, the life sciences and the materials sciences, which I think are well understood by people, particularly people close to the program, that will be done in the near term on this international facility—this is already an international program—that we are going to, in addition to be learning about those kinds of things, we are going to have to put this together. We are going to be learning about assembly on orbit. We are going to be learning about robotics on orbit. We are going to have to extend crew stay time up to six months. And the step toward six months is a step toward Mars, as far as I am concerned, and the next step beyond that is an extension of the life sciences research that this Nation has to invest, in, in order to do this facility.

So, space station Freedom is absolutely enabling in the context of the research that we need to do in order to get there.

Next chart.

But it is beyond that, and I would like to leave you with one other message about space station. We have examined both when I was at the space station program and the Office of Exploration has been coordinating this very closely with the space station office, and that is what about destination? Is it the right space station?

And you will recognize the baseline space station here with additional solar dynamic power. You have seen versions of this. And the old dual keel. We have looked at space station from the standpoint of what if we had to use it, what if we decided to use it as a hanger, an integration test and departure point for lunar spacecraft?

And here is one version that fits in with the scenarios that we have talked about going to the Moon where you actually see—and I will move over here—these two compartments are the places that would be used for the integration test and checkout for lunar vehicles.

Next chart, please.

[Slide.]

This is the same configuration with a modest variation in it, that would allow for a Mars vehicle. It happens to be bigger with just one vehicle in it because we are not making trips as often, and there is an aerobrake shield on the front of it that takes up most of the volume.

The message is, we have tested space station evolution, the two possible destinations that this Nation is considering going to. There are only two places you can go in the near term with humans. It's to the Moon and Mars. Space station Freedom is compatible with that in an evolutionary sense.

Next chart, please.

[Slide.]

And very quickly, what we are doing this next year. We are looking at three approaches basically:

We are looking at an evolutionary approach to Mars, where we still consider Phobos as an appropriate thing to use for resources to go down to the surface;

We are looking at an expedition to Mars, where we bypass Phobos and the moon, our own moon, in order to get there;

And we are looking at a lunar evolutionary approach, very much like we did last year.

The message out of this is that virtually all paths lead to Mars in some way, and we are still considering the possibility of actually using the moon in many of the ways we described earlier.

So, with that, I would like just to close my comments, and we can open it up for whatever discussion you would like to have.

[The prepared statement of Dr. Martin follows.]

Statement of

Dr. Franklin D. Martin

Assistant Administrator Office of Exploration

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications

Committee on Science, Space and Technology

House of Representatives

Mr. Chairman and Members of the Subcommittee:

Having appeared before this Committee during my tenure with both the Office of Space Science and Applications and, more recently, the Office of Space Station, I am pleased to be here today in a new role with the Office of Exploration. This new job provides the opportunity to integrate those past experiences in the manned and the unmanned world, both of which are important to the success of this endeavor and involves the efforts of virtually every element of NASA. I am looking forward to working with each of you and your staff members as NASA proceeds with its work in this area in the years ahead.

Over the past few weeks, you have heard from Dr. Fletcher and several program office managers regarding NASA's plans for the 1990s -- a time period that will become recognized as a decade of discovery. It is my purpose today to take you beyond the years when those plans will have reached fruition and to provide a preview of the potential for future achievements in human exploration that await us in the next century. Much work is still ahead, and any decisions for future alternatives for human exploration must be national in scope.

Following one of the recommendations of Dr. Sally Ride's "Leadership and America's Future in Space," NASA is documenting its study results in annual reports and developing the knowledge base that will permit informed recommendations and decisions in the future. Prior to the June 1987 formation of the Office of Exploration, such studies were generally pursued by ad hoc committees, which delivered reports and then disbanded: no formal mechanism existed for tracking progress or for building on the human exploration knowledge base.

The purpose of Office of Exploration is to study potential pathways to human exploration on a continuing basis and to coordinate this activity among the other NASA program offices. By coordinating these near-term activities the appropriate types of investments and programs can be pursued to enable a variety of pathways for potential future human exploration. Further, through the coordination of near-term activities, knowledge bases within the key NASA program areas are also being built which will permit a more informed decision regarding the eventual pathways to human exploration. These key program areas are:

SPACE STATION FREEDOM

PATHFINDER

LIFE SCIENCES

PRECURSOR MISSIONS

EARTH-TO-ORBIT TRANSPORTATION

POTENTIAL PATHWAYS TO HUMAN EXPLORATION

The National Space Policy established the long-range goal of the expansion of presence and activity beyond Earth orbit into the Solar System; however, this policy purposefully did not prescribe specific guidelines regarding the pathways, timing, or purpose. We could go to the Moon, to Mars and its moons, or we could choose unmanned missions. We could choose a plan for permanent habitation, or one for a faster mission with no lasting facilities. We could go alone or move into the Solar System as an international delegation. In order to formulate a logical plan to achieve the goal of human exploration, it is important to first investigate the mission possibilities.

The results of our FY 1988 studies are recorded in "Beyond Earth's Boundaries: Human Exploration of the Solar System in the 21st Century." This report gives a top level overview of potential exploration opportunities and options, as well as an assessment of the impact such opportunities might have on other NASA programs. For those who require more in-depth technical information, the results are also available in a separate three-volume series titled, "Exploration Studies Technical Report: FY 1988 Status."

To organize and systematically examine the full spectrum of options, three strategies, or alternative pathways, were selected for study in 1988. For each of the three exploration pathways, candidate missions were identified to be systematically examined as "case studies," in order to obtain an understanding of both near- and long-term implications of the potential approaches to exploration.

The case studies under our review were deliberately selected and defined to cover a broad range of objectives, options, and requirements, in order to gain a deeper understanding of the requirement of potential human exploration missions.

The strategies range from one-mission expeditions to long-term evolutionary programs. Some mission designs make use of existing technologies or those that will be available in the near future. Others require highly sophisticated new developments that are only now under study. The strategies are:

- o Human expeditions, emphasizing a significant, visible, successful effort to establish the first human presence on another planetary body. The expeditionary pathway would conceivably lead to exploration without the burden and overhead associated with permanent structures and facilities.
- o Establishing a science outpost, the second strategy, emphasized advancing scientific knowledge and gaining operational experience by building and maintaining a permanent observatory at an extraterrestrial outpost.
- o Evolutionary expansion would sustain a methodical, step-by-step program to open the Solar System for exploration, space science research, extraterrestrial resource development and, ultimately, permanent human presence.

Within the case study framework, detailed mission analyses and system engineering studies were performed to define a full set of concepts and requirements for each option. These analyses included an assessment of required environmental and scientific data, low-Earth orbit space stations, advanced technology, Earth-to-orbit transportation needs, in-orbit vehicles and assembly facilities, number of crew members and requisite life science research, and provisions for systems and activities to be conducted on planetary surfaces. Figure 1 depicts the three pathways for human exploration, as well as the FY 1988 case study options. The cases included Human Expedition to Phobos, Human Expeditions to Mars, Lunar Observatory, and Lunar Outpost to Early Mars Evolution.

During FY 1989, refinement of these cases are being reviewed including a modified Mars Expedition, Lunar Evolution, and Mars Evolution. We have also added a new expedition case to assess the scientific and resource value of human exploration of near-Earth asteroids.

In addition to reviewing specific case studies, our team, which has representatives from across NASA, is also conducting trade-off analyses of various techniques and capabilities that may be applicable to a range of missions. For example, what are the advantages of performing assembly operations on the ground, thus requiring heavier launch-lift capability versus launching smaller elements to be assembled in-space? Is there an advantage to be gained by producing rocket fuel from extraterrestrial resources rather than sending tankers from Earth? What is the feasibility of developing an artificial-gravity spacecraft, and what advantages does it provide not just for human physiology but also for low-Earth-orbit logistics? The result of such trade studies will lead to more effective mission planning.

Finally, we are cooperating closely with the space science community and with the Office of Space Science and Applications to identify how human exploration can advance science and application opportunities. In science, the disciplines being considered include planetary science, astronomy, astrophysics, space physics, solar physics, life sciences, exobiology, and Earth science. In the area of applications, we are concentrating on the potentials of resource mining and utilization.

The activities planned for FY 1990 will allow the Office of Exploration to continue to advance our knowledge base and understanding of the most advantageous way to meet the National Space Policy goal -- "to expand human presence and activity beyond Earth orbit into the Solar System."

Our study results exhibit significant contrasts between expeditionary and evolutionary strategies. Expeditions are very transportation intensive, with a major focus on the vehicles and systems to proceed to the destination. For the evolutionary pathway, operational transportation requirements are more modest and steady, and the focus is on sustained capabilities, systems, and facilities on the planetary surfaces.

When viewed in terms of prerequisite programs, however, all the cases share certain common requirements. The longer we delay a commitment to these prerequisite programs, the longer we will delay decisions on potential future long-term human exploration goals. I will now describe these prerequisites and their impact on the near-term NASA program.

SPACE STATION FREEDOM

The Space Station Freedom Program is the responsibility of the Office of Space Station. As a base to gain long-duration operations experience, as a laboratory to conduct the required life science research, and as a test bed to demonstrate technology, Freedom's contributions to potential future human exploration of the Solar System will be monumental. Bringing these capabilities to operational status within the currently planned schedule is essential to preserve our long-term exploration options. Since Freedom will also serve at some level as a transportation depot, we have been working with the Office of Space Station to define and understand the extent of its evolutionary requirements.

There are those who believe that the initial space station design and configuration should be delayed until a specific exploration goal has been selected. We have examined space station evolution and found that, regardless of the specific destination, the basic design requirements for the space station are the same. Space station evolution is driven by on-orbit operations and logistics, not destination. Just as you can go to Dulles Airport and select a flight to Japan or to Memphis, you end up using the same airport facilities: only the airplane and the amount of fuel required changes.

The Phase I Space Station Freedom design is appropriate and essential as a first step and could accommodate both Lunar and Mars options. Because of the large masses required in low-Earth orbit, our path through the Solar System will, of necessity, pass through Space Station Freedom. If it did not exist, we would have to invent a space station, because without it the most significant human exploration options would be foreclosed.

PATHFINDER

The Pathfinder Program, managed by the NASA Office of Aeronautics and Space Technology, is closely coordinated with efforts of the Office of Exploration. This program will enable numerous critical exploration mission capabilities in the areas of surface exploration, in-space operations, space transfer, and humans in space. A key element of our near-term investment strategy is to refine and focus the development of technologies required for potential future human exploration through Project Pathfinder. Advanced technology in the areas of surface exploration, in-space operations, propulsion, nuclear power systems, aerobraking, automation and robotics, humans in space, space transfer vehicles, and many others are being investigated.

The period between starting a major technology program and readiness for actual mission application can run from eight to twelve years. As Dr. Ride cautioned in her 1986 report to the NASA Administrator: "Until advanced technology programs like Project Pathfinder are initiated, the exciting goals of human exploration will always remain 10 to 20 years in the future." The Pathfinder Program is still in its initial stage; however, it is imperative that we sustain a commitment to this advanced technology endeavor.

There is a strong, on-going process within NASA to coordinate the advanced mission studies led by the Office of Exploration and the research and technology efforts being conducted by the Office of Aeronautics and Space Technology in Pathfinder. That relationship involves defining mission options and designs and the eventual development of these technologies to an sufficient level of readiness for application.

EARTH-TO-ORBIT TRANSPORTATION

A broad rage of future Transportation needs is being examined by the Office of Space Flight. Since all potential future human exploration missions will require the delivery of substantial amounts of equipment, fuel, and personnel to low-Earth orbit, investments in advanced launch systems, including heavy-lift vehicles, will be necessary. To meet the cargo transport requirements for the Mars expeditions, for example, launch systems with an annual payload capacity on the order of a million pounds will be required.

To reduce Earth-to-orbit operations requirements to a reasonable level, a vehicle with individual payload capacity of at least 91 metric tons (200,000 pounds) is being examined. In addition to Advanced Launch System class vehicles of which Shuttle C is one option, we are also examining an evolutionary version of such a vehicle that will allow masses to low-Earth orbit in the range of 250,000 to 500,000 pounds. Significant heavy-lift capability is essential to the mission options examined this past year.

Personnel transport requirements are still under study, but enhancements beyond current space shuttle capabilities are likely to be needed. The exact degree of this enhancement will be influenced by the amount of in-orbit assembly and processing that the crew will have to perform.

LIFE SCIENCES RESEARCH

Continuing research in life science is supported by the Office of Space Science and Applications' budget submission. To permit safe, productive, lengthy stays in space, a life sciences research program is of primary importance. In general, missions to the Moon are less demanding of prerequisite life science needs, primarily because of short flights and more flexible stay times. On the other hand, to support direct expeditions to Mars and Phobos, additional prerequisite research is required in such areas as low-gravity countermeasures, artificial gravity, space human factors, long-duration health maintenance, and radiation protection.

A very significant factor affecting vehicle design and crew capability is the long-term gravity environment that can safely be tolerated by the crew. There is currently significant uncertainty that the zero-gravity countermeasures alone will prove to be satisfactory for long-duration spaceflight to Mars or Phobos. Thus, artificial-gravity research pursued in parallel with our zero-gravity countermeasures program is a high priority. Allocation of resources for life science research on Space Station Freedom is a vital component leading to the potential future human exploration of the Solar System.

ROBOTIC PRECURSOR MISSIONS

Future precursor requirements and timing are being coordinated with the Office of Space Science and Applications. Potential future human exploration of the Moon and Mars will likely require a varying number and scope of robotic spacecraft missions that would collect information to characterize planetary environments. Such missions would define the conditions in which spacecraft and crew must function, serve as technology and engineering demonstrations, provide a basis for an optimized human scientific exploration, and provide visible milestones for a long-term program. We are currently analyzing a number of such missions, including a Lunar Observer and a Mars Rover Sample Return. These opportunities will be analyzed along with the results from past programs, such as Apollo and Viking, as well as ongoing activities, such as Mars Observer, and the results of other international programs to determine the exact precursor needs.

EXPLORATION PROGRAM IMPLEMENTATION STRATEGY

Developing a strategy to implement a program for potential future human exploration of the Solar System mandates the consideration of a time period of at least 20 years. Equally important are the near-term investments and studies that keep open promising options and opportunities.

Studies to date have placed priority on positioning this Nation to accomplish exploration goals in the first decade of the 21st century, while, at the same time, not allowing that desire to drive required investments in the nearer term beyond levels that are considered reasonable and practical. The strategy must be sensitive to the schedules of key prerequisite programs with associated demands for technical skills and resources. Thus, the strategy must effectively build on current programs, keep the demand for exploration-unique resources at a modest level, and still preserve a capability to act.

The program implementation strategy that meets these objectives naturally breaks into three phases: (1) defining and enabling multiple options; (2) initiating the long-lead development toward a specific option; and (3) developing the specific mission systems for initial exploration objectives.

Each phase has defined milestones, at which point accomplishments can be reviewed and assessed. This technique is structured so that future national decisions on the appropriate strategy can be made prior to proceeding to the next phase, with its increased commitment to required resources and expectations.

APPROACH TO INTERNATIONAL COOPERATION

It is clear that, whatever the course, the investment will be significant and the commitment required will be great. We have begun informal discussions with our traditional space partners on our respective future plans. The potential to share the costs and the rewards with other space-faring nations will be examined this year. A set of alternatives will be developed for further consideration. The exact approach to international discussions and any future participation will be developed in consultation with the Administration and Congress.

FY 1990 BUDGET REQUEST

FY 1990 funding for the activities pursued by the Office of Exploration is included in the budget line items of three programs: Pathfinder, Space Transportation Advanced Programs, and Planetary Exploration Advanced Studies. This funding supports studies which are consistent with the activities of the sponsoring program offices. Total funding planned for the Office of Exploration is $20 million. $10 million is planned for development and analysis, including mission analysis and synthesis support, planetary surface analysis, automation and robotics, cost methodology, space operations, and prerequisite program requirements definition. In order to reach outside the agency for new ideas and concepts applicable to human missions, we are introducing an Innovative Studies Research Program. The budget to support this activity will be $1.5 million of the Pathfinder funding. It is hoped that through this means we may identify new concepts and ideas which could have major impact on the performance, efficiency, or cost of future missions, which have not yet reached the recognition or state of maturity to be incorporated by NASA planners.

Five million dollars is planned from the within Planetary Exploration/Advanced Studies which will be applied to science and precursor studies such as Lunar science definition, Mars science definition, and tools and facilities research. The remaining $5 million will support efforts related to space transfer vehicles and is planned within the Office of Space Flight budget. This funding supports transportation systems integration, aerobraking applications, vehicle definition trade studies, and artificial-gravity vehicle studies. In related activity, the Office of Space Station is examining the evolutionary space station options, and the Office of Space Operations is working on communications needs.

CONCLUSIONS

Over this past year, we reviewed a range of case studies that served to test our assumptions concerning the capabilities that we need to have in place in order to ensure that this Nation can pursue the long-range goal of human exploration of the Solar System in the future. The results indicate that we must invest in Space Station Freedom, Pathfinder technology, life sciences research, Earth-to-orbit transportation, and precursor robotic missions.

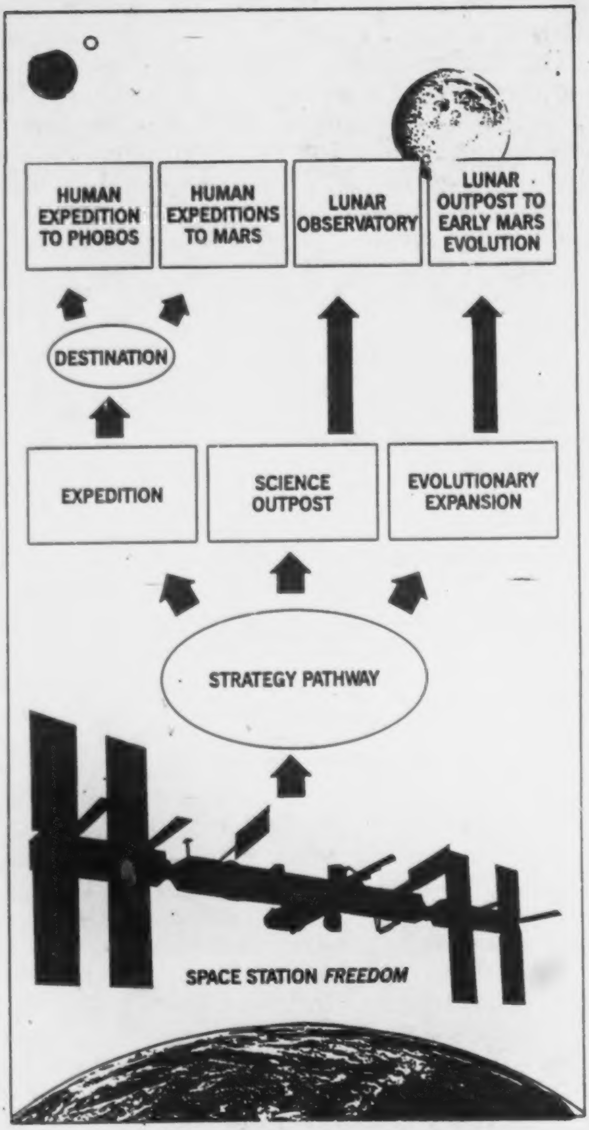
This next year we will refine our studies, concentrating on the Moon and Mars. We will examine expedition-class missions to Mars principally as a point of reference. Our long-range view is one that includes both the Moon and Mars with the potential of having permanent human settlements on both bodies at some future date.

In order to achieve such a long-range view, we are refining the Lunar and Martian evolutionary cases. The results of this past year have emphasized the importance of low-Earth orbit logistics and operations in all such efforts. This year we will examine transportation alternatives, the potential for remote fuel production, and the impact of an artificial-gravity Mars spacecraft on mission design.

The results will be used to develop sets of options involving the Moon and Mars that are reasonably scoped from the standpoint of annual mass to low-Earth orbit, technology readiness, and mission complexity and feasibility. At that point we will be ready to consider fiscal requirements and international alternatives. Progress of the past year has told us clearly what we need to do today to ensure and protect future options for potential human exploration of the Solar System. Many important elements, such as Pathfinder, Space Station Freedom, and life sciences research are included in the FY 1990 budget submission. Support for the NASA budget request of $13.3B is a step toward the future.

The results of this next year should yield reasonable alternatives that could be used as the basis for determining the scope and direction of our next steps in space. The next millennium is just around the corner. What lies beyond the Moon and Mars for human exploration, we can only imagine. But, whatever it is, we can be sure that the human spirit will drive our children, as we have been driven, to press beyond those boundaries that just yesterday were described as frontiers.

FIGURE 1. Exploration Pathways


HUMAN EXPEDITION TO PHOBOS
HUMAN EXPEDITIONS TO MARS
LUNAR OBSERVATORY
LUNAR OUTPOST TO EARLY MARS EVOLUTION
DESTINATION
EXPEDITION
SCIENCE OUTPOST
EVOLUTIONARY EXPANSION
STRATEGY PATHWAY
SPACE STATION *FREEDOM*

Mr. NELSON. What do you think about Franklin Chang Diaz's research on a plasma rocket that would take us to Mars in a month with a constant g force?

Dr. MARTIN. That would be wonderful. And of course, I know a lot about it—since you brought it up in the hearings the other day. It is one of a number of very advanced technologies that we are looking at in addition to the mission studies that you see here. The Lewis Research Center works for the Office of Exploration looking at propulsion across the board.

Nuclear electric propulsion, nuclear propulsion period, going back to some of the older Nirva systems that were tested out, I believe, in the '60s. And looking at things like this type of plasma device is one of those things we will look into.

And I would be happy to report back to you personally on how that all comes out.

But you are correct, if we could develop a system like that, then that would certainly help some of these problems. But I believe that particular device is well into the future in terms of advanced technology.

Mr. NELSON. Okay.

Members? Bob?

Mr. WALKER. Thank you, Mr. Chairman.

Do I understand correctly that you all have done some modeling of a potential Mars mission using the heavy-lift vehicle and so on which shows that we can probably go to Mars with relatively few lifts off Earth?

Dr. MARTIN. I believe you're talking about the vehicle I described as the 250,000 to 500,000 pound class.

Mr. WALKER. Yes. Could you talk a little bit about that, because I was interested in that as a configuration. It seemed to me to give us an idea that perhaps there are ways that we can do this without spending $60 billion to $100 billion, that if we are willing to invest in heavy-lift vehicles, all of a sudden we have some capabilities that allow us to look at probably a doable kind of national mission.

Dr. MARTIN. Let me caution you that even when you get beyond the transportation to orbit, things still tend to be a rather expensive proposition.

Mr. WALKER. Sure. But if we are talking about three missions to low Earth orbit in order to get a vehicle in place, or four missions or something on that order rather than 25 or 30, you really begin to change the dynamics, it seems to me, in terms of finding ways to fund it in the Congress.

Dr. MARTIN. Well, what we are looking at is a derivative of what has been called shuttle C. The shuttle C is a derivative of the shuttle, and shuttle C would allow us to put a cargo up of around 150,000 pounds into low Earth orbit.

It looks to us—and we are doing the analysis right now—that it may be possible to actually make the shroud of that shuttle C cargo carrier bigger and actually put what we call an upper stage or a kick stage in there and possibly stage off of that to put these larger masses in orbit.

That engineering analysis is under way. It is being done in house at the Marshall Space Flight Center. And it is one of the kinds of things that would give us the information we need to identify that as a hard requirement as something that we ought to be investing more time and effort into.

Mr. **Walker**. But if I understand the concept, part of it is a little like what you learned on Apollo, that the peeling off of pieces of Apollo became the way in which we were able to achieve the mission. But in this case what you're going to do is fully fuel a Mars vehicle, use that fuel as a part of the launch off of Earth, and then refuel in orbit? Is that it?

Dr. **Martin**. The way it would go is even if you could put up half a million pounds, you still have millions of pounds to go in terms of getting a Mar vehicle. And so some of the scenarios we have looked at would require five or six flights of such a vehicle to be assembled on orbit, coorbiting with the space station with the work being done not unlike the way I have described it to you here a bit earlier, and that those segments of the spacecraft would be actually fueled either on orbit or be sent up in some configuration that would allow us to fuel it.

And then with an additional shuttle flight to bring up the final crew, we could conceivably send a mission to Mars of the class that we have been talking about.

But I caution you that that still would be in the category of sort of possibilities. We are optimistic and hopeful that that may prove out, and we are working on it. But I think to say that there is anything possible beyond the ALS or the shuttle C-class vehicle at this time, we can't speak definitively on that subject.

Mr. **Walker**. One final area of questioning.

Is it absolutely essential to do the highest tech kind of vehicles in order to achieve? I am referring specifically to the big dumb booster. Isn't there some merit to looking at finding low-tech, maybe more inexpensive, highly reliable vehicles that could be used rather than pressing the levels of technology for virtually every aspect of one of these missions?

Dr. **Martin**. Mr. Walker, I have spent a lot of time with the unmanned world and trying to get payloads into orbit and things of this sort both on the shuttle and other things. The big dumb boosters make a lot of sense when you're talking about getting up your smaller payloads because that helps reduce the cost to somebody who is trying to get a communications satellite up, et cetera, et cetera.

When you start talking about a half million pounds or a million pounds in orbit, very frankly, it would be nice if they were big and dumb, but if they're not, they still make a lot of sense. They enable you to do things you just can't do otherwise.

So, a shuttle-derived kind of technology that could put up a half million pounds in simple terms in one flight because you have gone from a shuttle flight that can put up 40,000 to 50,000 pounds right now, talking about something that can put up 300,000 to 500,000 pounds, you've got a factor of ten already in terms of the cost benefit of being able to deliver a heavy-lift vehicle like that.

That same vehicle, though, may not make a lot of sense to try to put together. It includes together a lot of smaller payloads to do that. So, our interest in the shuttle-derived kind of technology is because we automatically get a benefit from an investment the Nation has already made.

Mr. **Walker**. Yes, I understand that, and I think that that is certainly something that probably may prove to be economically correct.

On the other hand, by using technology we know how to build, it becomes like off-the-shelf technology, and if in fact we could begin to do that and attract investors in to where we wouldn't have to be funding some of the technology but whereas it could be integrated into these missions, that also makes sense for us as a Nation to find the resources that we need beyond the $13 billion or $15 billion or $20 billion or whatever it is that this committee comes up with over the next period of years.

The other thing that I would simply stress is that one of the things that we learned when we went to see Arianne, when this committee went down to the see the Arianne mission, is one of the things that are doing with that is that they are building lower-tech approaches but then not stressing them as highly.

It seems to me that one of the things that we need to look at as a part of doing Mars missions and some of those is building technology that we don't have to stress within a inch of its existence, that we don't have to run a rocket's engines at 110 percent in order to achieve orbit and do some of those kinds of things that as we look at some of these missions for the future, we ought to be looking at technologies that we understress rather than overstress.

Dr. **Martin**. In fact, you are absolutely correct. And one of the things that we are having to pay attention to is the fact that not every year is a good year to go to Mars, as an example. And whatever system you design has got to be resilient to changes in those times such that you are not optimizing your spacecraft for each year.

My assumption is that we are going to Mars more than once. We are going to go in good years, and we're going to go in bad years. And having modular approaches and having systems that will respond and work with confidence is the thing that we are working on. We have got to have it.

Mr. **Walker**. Good. That's very, very good.

Thank you, Mr. Chairman.

Mr. **Nelson**. How, by the way, would you do a sprint mission to Mars?

Dr. **Martin**. The way a sprint mission works is the lowest-energy approach—I will explain the other version for you so you can appreciate the difference. The longer trip takes about a year and is about the most energy- efficient trip, which means the lowest mass in low Earth orbit. And that is where you leave the Earth and you sort of fly away from the Earth in what is called a Hohmann transfer orbit, and you fly for about a year and you come up and match up with Mars.

A faster way to go is to actually launch in toward the sun, in toward Venus' orbit, and swing around and you come out at a faster velocity with a shorter trip time on the order of six, eight months. But when you get to Mars, it turns out that you are moving at a velocity vector that isn't matched up directly with the orbit of the planet as it is in the other version.

So, it costs you a lot in terms of delta V fuel on board in order to get in orbit at Mars. And so you find out that those kinds of missions can sometimes cost you as much as two or three times as much in terms of energy as the lower-energy version would.

Mr. NELSON. So, the sprint mission takes you six months?

Dr. MARTIN. On the order of that.

Mr. NELSON. And the regular mission takes you about ten months?

Dr. MARTIN. About a year. And that is just one way. You've got to get home. A round trip, a round-trip mission to Mars on a sprint version is about 14 to 16 months, with about 20 days on the surface and a total of a month sort in the vicinity of Mars.

The Hohmann transfer version I described to you, the longer trip, you could spend up to a year on the surface of Mars before you came home.

Mr. NELSON. We will send this publication to the members of the committee as soon as we get enough copies, which is just off the press from Dr. Martin's office.

What are your current plans or schedules for soliciting foreign participation in these potential missions?

Dr. MARTIN. I described to you how we are working on these various case studies, refining the this year, and what we are focusing on is understanding what a reasonable scope, a reasonable scoped program could be, for these particular kinds of options involving the moon and Mars.

Now, I think that is terribly important because it doesn't make a lot of sense to me to bring you a program, the President a program that involves launching 20 heavy-life launch vehicles in one year.

I don't need to cost it out. I don't need to discuss how I am going to do that with the Soviet Union because it just doesn't make any technical sense to even pretend to be able to do that before you ever figure out you can't afford to pay for it.

So, what we are trying to work on right now is understanding what the scope of the program is and what our approach to costing is going to be on this so that we understand it, NASA does, the Administration does, you and your staff understand exactly what we are going to be talking about before we talk about $8 billion space stations and then try to match that up to the scope of the program. So, we are going to come at it with an understanding of the scope.

We are approaching the international cooperation in the same way. Jeff Rosendahl, who is here with me, has just joined us from John Logsdon's organization. He was there for a year and prior to that he was with the Science and Applications office of NASA.

Jeff's job is to begin the process, and he has already begun that, of looking at the experience we have gained from the space station program and other international programs, and he will be making a set of recommendations that we will carry forward to the Administrator that will be included—the results—will be included in this next year's report, which we hope to come out with around November or December.

It is my view that it is important that the Nation understand what the scope of this commitment is before we invite other Nations to come in and basically give them an opportunity to decide how to spend the taxpayers' money.

We are getting very close to that. I think we are in a position where possibly this next year, with the support of the administrator and the Administration, that we could conceivably begin a process of inviting other international or other countries to come and sit down with us and understand an approach to whatever the national goal turns out to be.

But I am on the track right now and of course it's my job to try to focus in on what a reasonable set of alternatives are and how we might deal with that from the national standpoint first.

Mr. **Nelson**. All right, Dr. Martin. Thank you very much for your testimony. This has been a stimulating day. Thank you.

Dr. **Martin**. Thank you very much.

Mr. **Nelson**. Thank you.

The committee is adjourned—Mr. Buechner? The committee is not adjourned.

Mr. **Buechner**. Don't run off, Doctor. I just wanted to ask you one thing.

I think you heard your predecessor in the testimony talking about dirty old moon versus scintillating, neat Mars. And I guess I have to agree with the sizzle part of it.

But do you think that from a life science standpoint and a halfway point that there is something to be said about the development of the moon?

Dr. **Martin**. The life sciences issues are a bit easier with the moon. It's only two and a half days away versus six months to a year. It can be thought of in many respects as far as life support systems as a space station that's two and a half days away. The moon has resources that we can consider mining and taking advantage of.

So, in that context, we could build on our space station life support capability in order to talk about having people on the surface of the moon. So, that aspect of it is easier.

Mr. **Buechner**. Lastly, I went to that space medicine conference that took place in Palm Springs a few months ago, and the Soviet scientists that were there, in talking about long-term space travel, were really quite skeptical, despite the fact that they had been in year orbit.

They were talking about the kind of thought that they have come to is that there is going to have to be the creation of some kind of artificial gravity for the human body to survive these long periods of space travel, whether it's osteoporosis or whether it's the development of gravel in the urine systems, the human body has developed a lot of reflexes to the zero gravity basis.

I was really quite stunned at their negative attitude. And then we ran into the polemic of well, does that what they really are trying to do here deter us from going into it, and I didn't think that that was what it was at all. It was sort of like one scientist said, I think it would be 50 years before we really do what we are talking about doing here.

What are we talking about in terms of a gravity provider if we are going to do a mission?

Dr. **Martin**. First of all, I believe right now that the principal way of going, the primary way of going, will be in a low-gravity spacecraft with countermeasures. I think that is the principal way.

We have a research program in artificial gravity. It starts out on spacelab on shuttle flights, and it will be followed up with a 1.8-

meter centrifuge on space station. There are plans, studies being done looking at larger centrifuges.

But I can tell you if we can design a one-g, one- atmosphere spacecraft to go to Mars, then there is no reason as a part of a Mars program that we can't test out a prototype of that vehicle in Earth orbit coorbiting with the space station prior to making that kind of a commitment.

What I am trying to do is to create a situation by understanding the engineering aspects of this tethered vehicle to create artificial gravity to make sure that this Nation does have an option, that we aren't just limited to the moon, that we have go beyond that.

And what we can do is, once we understand what those engineering trades are—and some of my people tell me that the cost of that vehicle may only be something on the order of 20 percent of what a vehicle that is a low-gravity vehicle might cost—then the trade-offs in terms of mass and orbit and other things may become very viable things.

So, I am pushing very hard on our folks to give me a yes or no on that artificial gravity capability. And if we can build one that can do one g, then we can build one that can answer the question about one-sixth g or one-third g, which is the gravitational field on the surface of Mars.

Mr. BUECHNER. Thank you, Doctor. I know I speak for the committee. We are ready to launch Commander Nelson tomorrow. [Laughter.]

Mr. NELSON. And he's ready. [Laughter.]

Thank you, Dr. Martin.

Dr. MARTIN. Thank you, sir.*

Mr. NELSON. The committee is adjourned.

[Whereupon, at 4:10 p.m., the subcommittee was adjourned.]

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*Appendix 4 contains additional answers to questions asked of Dr. Martin following this hearing of Mar. 9, 1989. See p. 1151.

1990 NASA AUTHORIZATION

TUESDAY, MARCH 21, 1989

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met at 1:40 p.m., in Room 2325, Rayburn House Office Building, Hon. Bill Nelson, chairman of the subcommittee, presiding.

Present: Representatives Nelson, Perkins, McMillen, Skaggs, Packard, Smith of Texas, Rohrabacher and Schiff.

Also present: Harry S. Dawson, Jr., Science Consultant, and Todd R. Schultz.

Mr. Nelson. Good afternoon. Today we are going to continue our scrutiny of the 1990 budget request. We are going to focus on the Office of Safety, Reliability, Maintainability, and Quality Assurance.

We had expected this hearing to concentrate on safety not only with the Office of SRM&QA, but had also asked the Aerospace Safety Advisory Panel to be with us, and we received a letter from them, dated March 17, that due to circumstances over which they had no control, that they were not going to be available on that date.

Most of the space community does have a fairly good idea of some of the items that were contained in that report and, as a matter of fact, we had had briefings over the course of time to our staff about some of their deliberations. So I will bring that out in the course of this discussion, and then we will see if we have an opportunity to have the Aerospace Advisory Panel to come and share with us their ideas on a number of things.

But specifically I am also interested in their report on the Advanced Solid Rocket Motors, which ought to provide some interesting commentary because I think that it has basically been critical, the Advanced Solid Rocket Motor.

Of course, this committee took a position last year supporting Admiral Truly's request for the Advanced Solid Rocket Motor, and so we need to know where the criticism is and what it's about, and be able to find out why. So we will be discussing some of that today.

Now, the funding for this office has basically been one of the smallest in the entire NASA budget, but it is an enormous responsibility that you have, Mr. Rodney, and we have talked with you at length, privately and publicly, about our wanting to support your efforts to see that your area of jurisdiction is carried out in a way that you deem that it should be.

Obviously there have been a lot of changes that have been made since the Challenger accident, and the degree of emphasis on safety is much higher. It was clear that there had to be major changes to correct the deficiencies that were identified in the investigations.

One of the questions that we're going to ask today is how well are those changes working? And now that we have had three successful missions, this is a good time now for us to begin anew the questioning of, as a routine starts to set in, that with regard to the safety and reliability, that we don't let a lot of the mistakes that were made with that ordinary routine, that we don't let them happen again; and then as we look to the future, the improving of the safety and the reliability of the improvements that are going to be made in the hardware as we continue on in the future.

So this is what we are going to dig into today. We will put Mr. Sensenbrenner's opening statement in the record. He is delayed in another hearing right.

Mr. Nelson. And you share with us in an opening statement—don't read us a statement—just talk to us, and then we'll get on in to the questions from the members of the committee.

STATEMENT OF GEORGE A. RODNEY, ASSOCIATE ADMINISTRATOR FOR SAFETY, RELIABILITY, MAINTAINABILITY, AND QUALITY ASSURANCE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY JAMES EHL, DEPUTY ASSOCIATE ADMINISTRATOR FOR SAFETY, RELIABILITY, MAINTAINABILITY, AND QUALITY ASSURANCE; AND DR. DALE UHLER, DEPUTY ASSOCIATE ADMINISTRATOR FOR SYSTEMS ASSURANCE SAFETY, RELIABILITY, MAINTAINABILITY, AND QUALITY ASSURANCE

Mr. Rodney. Mr. Chairman and distinguished members of the subcommittee, it is a pleasure for me to be here with you today to talk about our Safety, Reliability, Maintainability, and Quality Assurance Programs.

Nineteen eighty-eight was a very successful year. As you stated, we have the Shuttle back in safe operation, with three very, very good flights under our belt. We had six ELVs. We had some 79 sounding rockets and balloon flights. We had some very complicated missions. One TDRS, in fact now two TDRS—very successful—the X-29, the prop fan, very demanding flights over the ozone. All these and many others were high-risk programs, and I am happy to say we had no major test or operational failures or incidents that had real serious programmatic effect.

Now, one of the indices of how we well we are doing are the well-known OSHA statistics on accidents and incidents. I have a chart here that shows how NASA, this bottom line, this .37 for 200,000 hours compared to the all federal agency number, we're about seven times better than they are, and we are also significantly better than the aerospace industries. So it's just one little bit of indication that NASA is doing a good job in a lot of the details.

One of the things we have established in the last year or so is a very excellent system for handling data, for identifying problems, doing trend analysis, valuation, determining significant problems. Some of your staff have been to your Quality Management Information Center, and I wish you all could see it. We have established that system throughout the Manned Space Program, and we are developing variants of the system for the rest of NASA.

That gives us an open flow up to management, both in a direct sense, from a programmatic sense, and also as an independent that I have.

In addition to that, we do have an escape valve in the system, and that is the so-called NASA Safety Reporting System. You have pamphlets on your counter there. We have posters, a variety of these, all over which provide an anonymous method for people to report. And that system is working well.

It's well established across all the Shuttle programs and their major contractors, and during the course of this year we will get it spread across the rest of NASA pretty well. And it has provided us with some special insight—there have only been about 150 reports, about 90 of which were on the Shuttle, and about 6 percent of them were significant. None of them were the type that were a catastrophic failure-type thing, but they were significant and we needed to fix them.

I am also happy to say that safety and quality are a very active ingredient throughout the whole NASA process, from design, through test, through manufacturing, through operations. It's no longer a silent operation. At your request last year, we reconstituted the Ad Hoc Safety Review Committee and they, I believe, confirmed very well the fact that we do have a good system in being, and we are following up on all of their recommendations.

Just a few words on our budget. Our budget request is for $23.3 million, which is small in relationship to the total NASA budget, but it is very important. About one-third of that budget is spent to operate our Headquarters operation which develops policy, procedures, guidance, does audit, does independent assessment and overseas program performance. The other two-thirds is spent at the Centers on specific items that we designate them to support our operations.

Now, this year, for instance, we dedicated a nondestructive evaluation laboratory at Langley. About $3.0 million of the operating budget for that laboratory comes from this fund source. Our objective here is to make NASA the technology leader in nondestructive evaluation, which is a keystone of a quality system.

About $4.0 million of these funds go to four different Centers to work problems in relationship to the reliability of electronic piece parts and electronic packaging, which is a keystone of reliability in our business.

Another $2.0 million goes to software development at the Centers, software quality assurance and management problems. And the rest of it goes to a variety of tasks which further the technologies and the operations of the safety, the reliability and the maintainability functions.

We have had a year of solid accomplishment. We are faced with some very awesome challenges. One you mentioned: the fact that the maintenance of a safe operation of the Shuttle over a long term is a singular challenge unto itself. I have been in the business 40 years, and the Space Station represents probably one of the more challenging both management and technical challenges that I've ever seen. And that's one that we are faced with. In fact, right now I'm forcing myself and my senior staff to spend at least 25 percent of their time on the Space Station.

Commercialization, which is a new approach to life, and it provides some interesting challenges to my specialties, and how do we maintain the same level of mission success in an entirely new environment?

We need to keep improving our tools and techniques. Software quality assurance is an extreme concern of mine. The reliability, the long-lived reliability problems. We now are talking five-year, 10-year, 15-year, even 30-year programs, so reliability becomes a much greater problem.

We need to enhance our use of quantitative methods in support of our design and operations. All these are challenges that keep your adrenalin running. However, I am confident that with your support, we in NASA can meet those challenges.

In summary, I would just say that I am proud of the success that NASA is having. I am proud of the fact that we now have a proactive operation of safety and quality that is helping in that success. And I might add that my major concern, and one you also touched on, is how do we keep from letting complacency cause us problems?

That completes my opening remarks.

[The prepared statement of Mr. Rodney follows:]

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PRESENTED BY WITNESS

Statement of

George A. Rodney
Associate Administrator for Safety, Reliability,
Maintainability and Quality Assurance

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science, Space, and Technology
United States House of Representatives

Mr. Chairman and distinguished members of the Subcommittee:

I appreciate this opportunity to appear before you to report on the status of NASA's Safety, Reliability, Maintainability and Quality Assurance (SRM&QA) Program. When I appeared before this Committee last year, the Office of SRM&QA was primarily concerned with assuring the safe return to flight of the Space Shuttle and implementing the long-term corrective actions required to assure continued future mission success. I am happy to report that we have had a successful operating year. We have had three successful Space Shuttle flights and six expendable launch vehicle (ELV) launches. In other areas involving relatively high risk operations, we have had many successes such as the TDRS, the high altitude Antarctic ozone hole program, various aircraft research programs, and the balloon and sounding rocket launches. These have had no major operational or test failures that resulted in serious programmatic impacts.

In the coming year, we plan to continue the promotion of a viable and effective SRM&QA program throughout the Agency and its contractors, and thus continue to ensure the safety of the National Space Transportation System (NSTS). We will also be devoting a significant effort to ensuring that appropriate safety and reliability requirements are incorporated in the early phases of future manned systems, as well as current and future unmanned space flight and aeronautics programs.

During the past year, improving our risk management and problem reporting and resolution capabilities has had a high priority within my office. This has resulted in the implementation of improved safety and quality data systems; expanded use of trend analysis; strengthening of the Significant Problem Reporting System; and improved risk management approaches, including: a subjective rating system for Critical Items Lists (CIL's), fault-tree based mission safety assessments, and improved risk assessment procedures. Other accomplishments during the past year include issuance of the environmental impact statement for Galileo, dedication of the new nondestructive evaluation (NDE) laboratory at Langley Research Center (LaRC), and successful reassessment by the Ad Hoc Committee on Safety Risk Assessment.

Over the past year, I have completed the staffing of senior safety and quality positions. To strengthen the communication link between my office and the various programs within the Agency, personnel have been co-located with the major program offices at NASA Headquarters. These individuals actively participate in assessing the SRM&QA status of major NASA programs. The Office of SRM&QA also has assigned personnel to the Space Station Freedom Program (SSFP). These personnel are actively engaged in developing the infrastructure for the SSFP SRM&QA program. They are located at the Reston NASA facility to ensure close communication and active support and involvement with the SSFP. Many of the lessons learned from the NSTS are being applied in developing the SSFP SRM&QA policies.

While a considerable portion of our effort continues to be directed toward assuring the safety and reliability of the NSTS, increasingly more attention is being devoted to unmanned space flight and the aeronautics programs. Such areas as wind tunnel safety, facility and fire safety are also being addressed. Obviously, different requirements for safety are applicable to these programs than is the case for manned space flight. I would also like to point out that OSHA-type statistics show NASA with an outstanding record that is well ahead of aerospace and industrial norms. Elevation of the overall safety function to the level of Associate Administrator has ensured that the highest levels of NASA management are fully cognizant of significant safety and quality issues as related to all NASA programs.

During Fiscal Year (FY) 1989, the Office of SRM&QA experienced an increase in manpower and fiscal resources. The FY 1989 Headquarters budget focused on areas that affect NASA-wide SRM&QA functions, and supported the allocation of funds to NASA Centers and other organizations involved with these activities. The FY 1990 budget request of $23.3 million will permit the NASA Headquarters SRM&QA program to continue conducting those activities required to support the objectives of the Agency. This funding level will enable us to support an adequate management and oversight staff at Headquarters and support a variety of tasks at the Centers developing new methods and technologies; supporting test demonstrations of these developments; performing special studies and investigation of problem areas; and performing various activities essential to the conduct of a comprehensive SRM&QA program.

Since January 1986, we have been able to increase the number of NASA personnel directly assigned to SRM&QA functions by approximately 39 percent. There are now nearly 1,500 NASA Civil Service and Jet Propulsion Laboratory (JPL) employees in the total NASA SRM&QA work force. This number does not reflect manpower supplied by support contractors, any of our major contractors, or Department of Defense (DoD) SRM&QA organizations. The total authorized SRM&QA manpower level for FY 1989 is approximately 7,321 equivalent positions. This total comprises: 1,498 Civil Service positions at all NASA installations; 1,384 support contractor positions; 4,012 position at the major contractors; and 427 SRM&QA positions allocated to DoD.

In addition to funding required manpower, this budget will support the initiation of work to enhance technologies that contribute to improved safety and quality, such as NDE techniques. We have encouraged the use of new NDE inspection and quality control techniques to evaluate the integrity of complex designs, advanced materials, integrated electronics, and manufacturing processes. A new NDE laboratory was dedicated this year at LaRC. A few of the areas where we have successfully applied advanced NDE technology are: the ultrasonic bolt monitor used to measure preload in fasteners such as those used on the Shuttle wheel bolts and external tank; inspection methods to detect debonds in the solid rocket motor (SRM) case/insulation/fuel interfaces; and ultrasonic techniques for inspection of low velocity impact damage to composite structures. These advanced technologies have already provided a payoff in the improved inspection techniques for ensuring the safety of the Space Shuttle.

Policy requirements for risk management for manned flight were completed this past year. As a result of these efforts, we have issued a NASA management instruction (NMI), "Risk Management Policy for Manned Flight Systems" (NMI 8070.4). This policy states that the latest proven analytical techniques are to be used in the development and operation of safe and reliable space systems. The policy provides the framework within which a variety of quantitative and qualitative analyses may be used, and establishes a hierarchy of methods as follows: qualitative methods such as hazard analysis and Failure Modes and Effects Analysis (FMEA)/CIL; a hazards categorization and prioritization system based on engineering judgment, qualitative fault-tree analysis, and use of quantitative risk analysis methods where sufficient data bases exist. We have also drafted risk management policies for unmanned flight systems, research and technical facilities, and roles and responsibilities. These policies will be published later this year. Work also has been completed on a draft risk assessment tools and techniques NASA handbook (NHB), guidelines for enhanced hazard analysis of space systems, and two draft directives on human engineering: "Basic Procedures and Responsibilities for Human Engineering" (NMI 8070 series) and "Human Engineering Requirements for Manned Space Flight Systems, Equipment, Software and Facilities" (NHB 8070 series). Proof-of-concept probabilistic risk assessment studies were also conducted on hydraulic power unit/auxiliary power unit. In FY 1990, we plan to continue to strengthen this area of SRM&QA through integration of requirements into program/center documentation, increased training in risk management and human factors engineering and in development of probabilistic risk assessment models. These improved techniques will be used extensively on the Space Station Freedom (SSF).

An area of concern within the aerospace community has been the availability of space quality electronic parts. As reported last year, this problem has affected both the NASA and DoD programs. Therefore, we have established a NASA Standard Parts Program with the objective of increasing the availability and reducing the cost of space quality parts through standardized part usage. To accomplish this objective, we established the NASA Standard Parts Project Office; became full partners in the DoD Military Specifications system; completed a NASA/DoD Memorandum of Understanding that will increase the availability of space quality parts by providing for a class "S" stocking program; participated in a NASA/DoD supplier audit and certification activity for space quality microcircuits and semiconductors; issued NHB 5300.4(1F), "Electronic, Electrical, Electromechanical (EEE) Parts Requirements;" and developed EEE Parts documents controlling procurement, selection, and application criteria. Effort is currently being directed toward expansion of the audit and certification activity to include passive devices such as resistors and capacitors, development of a family of standard radiation-tolerant microprocessor components, and the development of a NASA-wide EEE Parts information management system. NASA has been the leader in defining and quantifying the single event upset and total radiation dose phenomena on electronic components.

Reliability, maintainability and quality assurance are keys to the SRM&QA program. To strengthen this area, the Office of SRM&QA has embarked on an aggressive program to improve our basic capabilities and establish firm policy guidelines. Basic policy requirements were completed in FY 1987. During the past year, we issued NMI 5350.1, "Maintainability and Maintenance Planning," to provide additional guidance. NHB 8071.1, "Fracture Control for Payloads Using NSTS," was also published. Agency policy on software management assurance, mission-critical software security, critical fastener procurement, engineering standards and commercial ELV's is currently being addressed. We are also developing a generic failure rate data base to improve our ability to perform quantitative predictions for reliability trade-offs, initial spares estimates, and support for risk assessment.

Effective SRM&QA depends on maintaining a strong, basic and energetic technical capability within the Agency. In FY 1990, the Office of SRM&QA will undertake initiatives to identify key areas for improving technical capabilities and initiate pilot projects in selected areas. This will be accomplished through the upgrading of technical resources and technologies in: materials treatments and processes; inspection and control of multi-layer board design/fabrication; inspection and quality control techniques for microcircuits/semiconductors; methods for fracture control; electronic packaging technology (e.g., surface mount technology, pre-cap visual inspection by NDE, and automated solder assemblies); and definition of "on-orbit" NDE/metrology requirements.

Essential to ensuring the safety and reliability of both manned and unmanned systems is effective communication of both problems and data. We have accomplished this by: developing a tracking system for open problem reports coupled with the improved Program Compliance Assurance and Status System (PCASS); enhancing the Mishap Reporting and Corrective Action System (MR/CAS); and expanding the scope of the NASA Safety Reporting System (NSRS), which provides an additional avenue for NASA and contractor employees to communicate safety concerns. We have also completed the requirements/conceptual plan for the NASA Safety Information System (NSIS), which will enhance our capability to provide closed loop tracking of safety issues and better use of lessons learned.

In the past year, the Office of SRM&QA has been able to strengthen our capability to identify open problem areas, report/record significant problems, and analyze data trends. An essential element of the NASA SRM&QA effort is the recording and tracking of open problems. Open problem status reports have been established for the Orbiter, Space Shuttle Main Engine (SSME), External Tank (ET), Solid Rocket Booster (SRB), SRM, government furnished equipment, and Shuttle processing operations. Open problems are tracked in terms of criticality and closure status. The most serious of these problems are identified and tracked through the Significant Problem Report (SPR). The SPR is provided via the NASA/contractor community, and is independent of the programs being monitored. Requirements have been drafted and partially implemented to extend the SPR system to ELV's, payloads, aeronautical systems, and facilities.

Summary information on all open problems and SPR's are displayed in the NASA Headquarters Quality Management Information Center (QMIC). The QMIC, based primarily on information contained in the SPR and PCASS, provides the necessary visibility to management. In 1988, QMIC's were established at Kennedy Space Center (KSC), Johnson Space Center (JSC), and Marshall Space Flight Center (MSFC). This approach provides the same level of problem visibility to center management that is available to senior NASA management through the QMIC at Headquarters. QMIC's are planned for SSFP (Reston), Goddard Space Flight Center (GSFC), and Lewis Research Center (LeRC) during FY 1989.

The NSRS, which is our confidential, voluntary, supplementary safety reporting system, was implemented in the spring of 1987 to handle safety concerns relating to the NSTS. The NSRS is patterned after the Aviation Safety Reporting System (ASRS), which NASA operates for the Federal Aviation Administration. It is administered by an independent, neutral agent: the Battelle Memorial Institute in Columbus, Ohio. Battelle's NSRS staff processes all incoming reports and maintains the data base.

The first expansion of the NSRS occurred in February 1988 when the NASA facilities and contractors responsible for Shuttle payloads were brought into the system. By the end of September 1989, all NASA and contractor facilities involved in the SSFP will be included in the NSRS. The expansion of the NSRS will be completed by September 1991 when ELV's, aeronautics, and research and development facilities will have been added to the reporting community.

While the expansion ~~program~~ is far from complete, no safety issue reported to the NSRS (regardless of the program affected) is ignored. All reported safety concerns are evaluated for validity and criticality, and appropriate corrective measures are developed and implemented.

I am pleased to report to you that the NSRS was fully operational during the processing of OV-103 for our return to flight. I have been very satisfied with the quality of the reports submitted and the seriousness with which the reporting community has accepted the system. Fewer than 5 percent of incoming reports are categorized as cranks. The status of open reports is specifically addressed during Flight Readiness Reviews.

As the system expands into other NASA facilities and programs, we are confident that it will provide us with information of continued value to our safety assurance function by providing a bypass mechanism for those individuals who believe that our normal reporting systems cannot or have not been responsive to their perceived concerns.

The MR/CAS is our automated collection and retrieval system for data generated from mishaps and close calls. All NASA field centers and the JPL are now on-line and able to transmit their mishap data electronically to the Office of SRM&QA.

The primary objective of the MR/CAS is to expedite correction of potentially hazardous situations through early identification of trends. The system enables safety managers at each facility to make maximum use of their mishap data by allowing refined data searches and a wide variety of standardized as well as customized reports and graphs. For example, the MR/CAS provides a standardized report for the evaluation of contractors' lost-time performance and major mishap experience for a particular quarter or year. The same capability exists for individual NASA organizations within each center.

During the past year, we have reinforced the requirement for reporting and tracking close calls. These are defined as occurrences that result in no injury, no damage, no significant schedule impact, but have the potential for a much more serious mishap. Close calls require the implementation of a corrective action plan just as all mishaps do. The development of a close call data base will allow safety personnel to study trends and implement measures that will prevent serious mishaps.

A year ago, I stated that in response to your request I had reconstituted the Ad Hoc Committee on Safety Risk Assessment for the purpose of revisiting and updating the issues and findings disclosed in their initial report. The final report was published, as per schedule, on July 1, 1988. The results validated that the corrective actions and systems put into place for resolution of problems and findings of earlier oversight committees were successfully implemented. We plan to continue monitoring these systems to ensure that complacency does not become a factor with the increase in launch rate.

A key activity within the Office of SRM&QA is the independent technical assessment of the problems that could have an adverse impact on the operational/mission success of NASA flight and ground systems. The objectives of the independent systems assurance function are to provide a "second look" at significant problems and issues through the use of reviews, studies and technical analyses; and to ensure that the corrective action plans proposed to solve these problems are technically accurate and timely. This independent assessment process will selectively review issues throughout the entire NASA development and operating process including design, development, manufacturing, procurement, test and operations. NASA SRM&QA has been fully involved with items such as the redesign and evaluation of the SRM seals, outer boot ring nozzle assembly, SSME turbine blade cracking problems, and the orbiter/external tank 17-inch disconnect. Other independent assessments conducted include assessment of the Galileo radioisotope thermal generator (RTG) accident scenario probability estimates, review of the JPL SSME certification study, and review of the Rockwell International (RI) critical function audit of the SSME. In FY 1990, we plan to continue independent technical assessment of issues and problems that could have an impact on mission success and safety. Also, we plan to establish a common policy for systems assurance for all NASA programs and selected contractor activities. We will develop an overall audit, policy, plan, and program for the Agency, and perform selected audits of programs and field centers.

In conclusion, our major asset for ensuring that safety and reliability are foremost in all NASA programs, is our personnel. The initial efforts of the Office of SRM&QA were devoted to organizing and staffing the SRM&QA function within the Agency for support of NSTS. The major continuing goal is to establish SRM&QA program structures with adequate funding levels that will ensure the continued existence of an effective SRM&QA organization within NASA. This will not only ensure the safety of current programs, but will also ensure that reliability and safety requirements are adequately considered in the early phases of future programs. Thus, we will ensure that mission success is achieved safely and economically.

The major challenges I see before us is to assure that we have the funding level that will enable us to: develop and promote a reliability and risk reduction program that will help assure the continued success of the NSTS program; ensure the proper focus and resource allocation for SRM&QA and test for the SSFP; implement improved approaches to hazard analysis, risk assessment and quality assurance of both hardware and software; ensure that the concerns for safety and quality assurance are not adversely impacted due to lack of management attention or curtailment of resources; and ensure adequate SRM&QA oversight in privatization and commercialization projects.

Mr. Chairman, this completes my prepared statement. I would be pleased to answer any questions you and other members of the Committee may have.

Mr. **Nelson**. Thank you, Mr. Rodney.

Mr. Volkmer.

Mr. **Volkmer**. Do you have any concern with the budget as far as being able to continue the programs that we now have in place for 1990?

Mr. **Rodney**. No. The budget we have—it is tight; there is no question about it. Like anybody, we could always spend more money. However, we can operate a safe operation, utilizing the money that is available. Some things we could do a lot faster if we had more money, but I cannot state that with this budget I am in extreme peril of any sort.

Mr. **Volkmer**. Does your office have people in position at all of the Centers?

Mr. **Rodney**. Yes, sir. The bulk of our activity is obviously done at the Centers. And we have the parallel of my organization in place at each of the Centers, and obviously they also manage the appropriate safety quality operations of the contractors.

Mr. **Volkmer**. The proposed budget is a reduction from what you all submitted to OMB.

Mr. **Rodney**. That is correct.

Mr. **Volkmer**. Are you telling me, then, that you padded it before it went to OMB?

Mr. **Rodney**. No, not in the least. As I say, it is a question of how fast you can put improvements into the system. We have been improving the system at a rather substantial rate. We had a significant increase in the '88 budget that allowed us to accelerate some of our activities, and the difference between what we asked for at OMB and what we have today is really representative of how fast we can get items in place.

Mr. **Volkmer**. Does the safety measures, quality assurance, all that that you operate under your office go into the contractors' floor also?

Mr. **Rodney**. Are you referring to the $23.3 million?

Mr. **Volkmer**. No. I'm talking about now the actual workings of the office. In other words, if you've got somebody out there, a contractor, subcontractor, what have you, making something for NASA, does your office go into that to determine whether the safety concerns are being met? Or do you to make recommendations to them for safety enhancement or whatever?

Mr. **Rodney**. We review the operations of the contractors. We also review whether we believe they have sufficient resources being applied, and we work with the program offices who obviously control their finances, and if we feel there is a deficiency, we work with them to get those deficiencies rectified.

Mr. **Volkmer**. All right. Now that I get a pretty good picture where your office operates in this whole realm of the NASA operation, we get back now to the $10 million or so. In that whole realm, where aren't you going to be able to do things as well or as fast as you had planned to do?

Mr. **Rodney**. Well, you heard me mention earlier software quality assurance. That's a very complicated issue. It's not fully developed. We're still struggling with what are the best techniques for controlling software quality and that is becoming a much more important issue because as computers become more and more the operating system of all of our programs, the issue of human error is being replaced really by the potential of computer error. And we need to penetrate that issue.

Now, we are spending, as I said, somewhere around $2.0 million this year on that type of thing. In the OMB issue, we had asked for, I think, another $1½ million, in that area. In the area of electronic reliability, we had asked for some additional money to work electronic packaging, some more advanced states of electronic packaging. How do we inspect them? How do we make sure they're good? And the amount of money we have available to do that is significantly less.

Mr. VOLKMER. What you're telling me is that some of your money that you had planned to spend is actually going into analysis basically, your computer reliability, et cetera, to determine what needs to be done. Is that correct?

Mr. RODNEY. Yes. There are longer range issues.

Mr. VOLKMER. Unresolved issues?

Mr. RODNEY. Oh, yes; in practically all cases. Some of the things would be in support of the Space Station. For instance, how do we do on-orbit inspection and how do we do on-orbit calibration of instruments? You have instruments that are going to be up there for, say, 20 years, which ordinarily on earth we calibrate every six months or so. We don't know quite how to calibrate them.

The issue of fire and fire suppression in zero gravity is an issue. We are spending some money on it. We could spend more on it if we had it available.

Mr. VOLKMER. Thank you, Mr. Chairman.

Mr. NELSON. Thank you, Mr. Volkmer.

Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman.

You alluded, Mr. Rodney, to the fact that one of your concerns is how do we move into the privatization and commercialization of space and still maintain the quality assurance and safety oversight.

Do you have some suggestions on how—I think it is obvious we are going to move more and more into commercialization and the private sector doing more and more of some of our space activities that heretofore has been reserved to NASA.

What do you see the future for your Department? Is it reasonable to consider removing, for instance, your Department from NASA and putting it over all forms of space travel and space activity, separate and apart from NASA, or do you feel that NASA ought to take the role of monitoring and evaluating the safety factors and safety activities and quality assurance activities for the private sector? How do you see that playing out?

Mr. RODNEY. My thoughts—I haven't been on the grosser picture as you outlined—I have been worrying the thought that where NASA is involved, and we are going to have a payload on a commercial launch vehicle, for instance, what is our responsibility on determining whether that launch vehicle is ready for flight?

We go through a very, very elaborate review of, say, the Shuttle before we fly, or one of our own ELVs before we fly, to determine that we are absolutely satisfied we are ready to go fly.

In the area of commercialization, the degree to which we are either responsible to determine whether it's ready to fly and if we have some degree of responsibility, how do we penetrate the system so we can have a confidence factor? And that is the issue I've been working on.

I don't have pat answers. Part of the reason is that we don't have fully firmed up, in most cases, commitments as to how the whole agency is going to operate, and we are just a part of that.

Mr. Packard. But surely down the road, we are going to see more and more ELVs launched outside of NASA's jurisdiction and possibly even at some point in the future, even though it may be questionable, we may even see manned vehicles in the private sector several years from now that would not be under the jurisdiction, neither military nor NASA launches.

We are going to have to probably sift through some fundamental policy decisions relative to whether we have a dual system set up on quality assurance and safety, one for the private sector and, of course, continuing for the public sector; or are we going to have one that would oversee the entire process, over both processes, the private versus NASA.

Apparently that has not been well thought through at this point.

Mr. Rodney. That is correct. That is one of the issues that I say is one of our challenges for this year. I hope we can formulate some—but these are policy decisions and you all will undoubtedly get into it.

Mr. Packard. Do you feel, Mr. Rodney, that as we begin to look at legislative strategies to accomplish the privatization, commercialization, some of which we started last year with the chairman's legislation, do you see where this aspect ought to be addressed in the initial phases of legislation authorizing some commercialization?

Mr. Rodney. Yes. There has to be some very definite determination of the responsibility for mission success and who is liable. In other words, if we put a $500 million experiment on a commercial launch vehicle, I want to know for darn sure what is my responsibility in that role there. And we do need to determine that.

I can implement the responsibility probably fairly easily. It's the question of what is the specific responsibility.

Mr. Packard. I see that as an interesting process that we can't overlook as we move down the road.

No question that one of the primary concerns of the moment in this hearing is the ASRMs and what we see now coming out as a concern, an expressed concern of their safety. I would like your comments, if I may, on what seems to be emerging in reports and whether in fact we need to re-look at the ASRM program to determine whether it's feasible, whether it can be made safe, whether we ought to proceed. Your comments, please.

Mr. Rodney. If I answer strictly your question, I know of nobody that has challenged the thought that the ASRM would be less safe or less reliable than the existing system. I know of no one who brought up that issue.

It is pretty fundamental that, given the 10 to 15 years that has passed since the existing Solid Rocket Motor was designed, that we are smart enough to design a technically better system. We are also smart enough to design it in a fashion that the manufacturing of it can be more reliable, and in all probability it will have better performance.

Now, I don't know of anybody who has challenged those fundamental issues.

Mr. PACKARD. Then you are suggesting that we can make it as safe as the existing ARMs.

Do you feel that we can improve as we develop?

Mr. RODNEY. Yes. The inherent reliability of a new design would have essentially better inherent reliability than the existing one. Now, the question you get into in reliability is what is your achieved reliability. You get those numbers, of course, through experience.

Now, at a point in time when we fly the first ASRM, we will have had 50, 60 flights of the RSRM under our belt, and so even though the inherent reliability of that first ASRM may show on paper to be higher than the RSRM, the actual achieved reliability will be less. You won't be as confident flying that first one as you would flying an RSRM. It's just the nature of the business.

Mr. NELSON. Would the gentleman yield on that?

Mr. PACKARD. Yes.

Mr. NELSON. It has been suggested that if a policy decision is arrived at that we need a Shuttle C, that with the less performed reliability that you're talking about, even though the inherent reliability is there, that you may want to use the ASRMs first on an unmanned Shuttle C version as opposed to the manned Shuttle.

Mr. RODNEY. As a professional safety man, I would love it. One of the difficulties of the Shuttle system is that we don't have an ability to fly an all-up test in an unmanned condition.

So, yes; very much so, I would support the idea that we could somehow fly the first ASRMs in an unmanned condition.

Mr. PACKARD. Mr. Chairman with your permission—have there been tests performed already, or are there ongoing tests as we develop the ASRM to determine its reliability and its safety in the early stages of development, or is that possible?

Mr. RODNEY. There has been an ongoing Solid Rocket Motor Improvement Program going on at Marshall for some time, developing new technology or verifying new technologies.

Now, I'm not sufficiently briefed on the details of that to talk to you. J.R. Thompson would be happy to discuss the details of what they've been doing in that area.

Mr. PACKARD. That's all I have, Mr. Chairman.

Mr. NELSON. Let me just follow up the comments on the ASRM. There seems to be some debate as to whether or not the ASRM is more safe or less safe than the redesigned Solid Rocket Motor.

What do you think?

Mr. RODNEY. I will reiterate. The inherent safety or reliability of an ASRM would be higher than what we can probably achieve with the RSRM, but at a point in time the numbers will be reversed to a degree.

Mr. NELSON. What sort of guidelines would you set to ensure that ASRM is safe?

Mr. RODNEY. The prime issue on the ASRM will be to have a very thorough ground test program. It will have to be essentially the equivalent at least of the amalgamation of the programs that we used in the development of the SRM and the RSRM, so it would be an extensive ground test program.

Now, I can't tell you whether I want six full-scale firings, or eight, or four, but it will be a significant number.

Mr. **Nelson**. Something like what we went through for the redesign?

Mr. **Rodney**. Yes, sir.

Mr. **Nelson**. And you would have that done before the ASRM flew?

Mr. **Rodney**. Oh, yes, sir. Yes. It has to be fully-qualified. I don't believe you'll find anybody arguing that.

Mr. **Nelson**. Mr. Rohrabacher.

Mr. **Rohrabacher**. Thank you, Mr. Chairman.

After all the testing and everything that we are going through to make sure that this new system is safe, when all is said and done, what are the costs on the ASRM as compared to what we have now with the RSRM?

Mr. **Rodney**. I'm not qualified to answer that question. I try to keep out of that. My job is to espouse the safety and the quality features, and I like to try to let the program people——

Mr. **Rohrabacher**. I guess what I'm trying to get at is if we get a certain amount for safety, how much is going to cost us for that? You know, there's a cost and benefit ratio there. It's well worth it, obviously.

Mr. **Rodney**. I am not capable of answering that. We don't really work cost/benefit studies in that sense very often.

Mr. **Nelson**. Let me go back to the ASRM. Have you seen this Aerospace Safety Advisory Panel Report?

Mr. **Rodney**. Yes, I've seen drafts of it. Of course, I have lived with the committee. I go to a good many of their meetings. Primarily I do that because they provide me with instantaneous source—I'm not interested in one time of the year data dumps, so I try to glean what their thoughts are as they form them.

Mr. **Nelson**. What do you think we should do to address their concerns?

Mr. **Rodney**. I believe you will find that none of their concerns are strangers to you. In other words, they are all either concerns that you have heard or observed through your normal proceeding. In other words, I don't know of a single surprise in the report.

Their treatment of the ASRM is not that they're against it technically per se. I don't believe you will find anything there that is a total surprise.

Now, their counsel is extremely valuable. I use their counsel all the time and many of my decisions they help me formulate in a context of there are a lot of sharp gentlemen on that panel, and I get a lot of very sage advice which I heed in many cases. And some of the things that we do on a day-to-day basis are things that I picked up from them.

Mr. **Nelson**. I take it that one of the things they say is that for the money that we would spend on doing an ASRM, we could use that money doing things safer, making things safer in other parts of the whole Shuttle system.

So my question to you would be: Are there other safety improvements that we should fund that in your opinion have a higher priority than the ASRM?

Mr. RODNEY. This has been an issue that I have raised within NASA as to what is, given a fixed amount of money, what things should we be spending money on?

Number one, I cannot in my position tolerate the thought that because an ASRM is coming down the line, that we stop improving the existing RSRM. Whether any of us like it or not, we are going to fly 40, maybe 50 flights with the existing RSRM. There are some design improvements we can make. There are some manufacturing improvements we can make. There are some very needed inspection techniques that we must make in that area. And I have got to keep insisting that we keep doing that.

Then there is the trade-off that we have of a large number of very desirable changes that could be made to the orbiter, to the SRB, to the SSME, and my argument there again is that many of these I don't want to see done on a budget available basis; I'd like to see us pushing them on a technically available basis to get them into the system so that we can reduce the risk.

We all acknowledged that the Shuttle is a relatively high-risk program and we need to keep putting money into it. We're going to be flying the Shuttle, by every indication, into the next century and we need to keep continually upgrading the system. There are a lot of design features. We know a series of things like the drag shoots and improved brakes and improved landing gear and things of this nature to make the landing safe, which is a high-risk area system.

The APUs in the Shuttle, there are many things we probably could do to reduce the risk of those units. On things of this nature, I would like to see us keep pushing. And the only issue that I have ever raised on the ASRM is that we equate the total amount of money that we may have available—and this is a decision, a mutual problem here—that we cannot afford to get to the point where we're stagnant in improving the existing program.

Mr. NELSON. Other things like the structural integrity of the wings, the vertical stabilizer, and so forth. And so when you go allocating money for that, which is what we have to do, advise us. Within limited funds, where is the best to put the emphasis on the safety? If the question is, does it get absorbed for an ASRM or does it go in these improvement programs; or should the question be framed that way at all?

Mr. RODNEY. There is another side to the ASRM issue that we cannot lose sight of, and that is the fact that we do need added performance. The Space Station especially needs the added performance uplift capability, and so the ASRM is a very significant answer to the performance problem. It may not be the only answer, but it is a very significant answer to the performance problem.

In the total analysis, it's not strictly a safety and quality issue. It's a total program issue. So I don't want to overemphasize the thought that I have the only input.

Mr. NELSON. Let me ask you this. What has your NASA leadership said to you when you have raised these issues about the allocation of these resources down the line?

Mr. **Rodney**. They have recognized the issue and we have had many internal discussions on the subject. At the present time, the consensus is that the ASRM is still the logical path to take.

Mr. **Nelson**. You're talking about the improvements on the present redesign SRM. Now, what has your leadership said to you when you recommended these improvements and therefore the spending of money on the present production facilities for the SRM?

Mr. **Rodney**. There is money being spent. Right now we are moving ahead with just about all the improvements I know, for instance, on the RSRM. Don't get me wrong.

The issue that I am concerned about is if the budget gets more constrained for any reason whatsoever, as to whether we start cutting back into the existing plans.

Mr. **Nelson**. What about the facility upgrades?

Mr. **Rodney**. Well, the facility upgrades, a large part of that depends upon Morton-Thiokol because, in essence, a lot of that I trust will be capital improvements by Thiokol, although we also have to support it because the program peculiar hardware is a program funding issue. But it is a two-way street.

Mr. **Nelson**. Thiokol has to have the approval of NASA.

Mr. **Rodney**. Well, yes, because if they want to change a process, we have to agree with the process. In essence, yes, they need it.

Mr. **Nelson**. So what is the leadership going to do on this and what is your recommendation to the leadership?

Mr. **Rodney**. Well, as I say, what I recommend is that we keep moving ahead with a variety of these changes. Now, part of my job—and I haven't completed it—is providing the leadership with a better, shall we say, totem polling of the integrated list of changes. In other words, not just looking at the orbiter as one unit. You have to look at the orbiter, the SRB, the SRM, the SSME, and say how do they stack up? What changes from each one? And that is a very difficult task of trying to sort that out.

We have been actively working it. I had hoped to have an answer before these hearings, but I quite frankly don't.

Mr. **Nelson**. This committee needs a specific answer to know what NASA is going to decide with regard to the improvement of those facilities. We've got to fit this all into the matrix to try to understand this whole thing on ASRM, and I could keep asking questions on that, but let me turn to Mr. Perkins.

Mr. **Perkins**. Mr. Chairman, I was actually very interested in your line of questioning. I am still not clear in my own mind, and it seems like I'm beating a dead horse here, but as to the prioritization NASA is giving the RSRM versus the ASRM in the budget allocation process.

Now, your testimony, as I understand it, said that you think you have to spend money on the RSRM as you go along. That is obviously important because there are some design changes you want to make, with other changes you want to make.

The ASRM, you said, is something that eventually is going to be safer than the RSRM. If in fact there is a budget crunch of some sort, do we put the money in the RSRM first?

Mr. **Rodney**. As I say, it is not a singular safety and reliability decision. That is a program decision that involves many, many aspects.

Mr. **Perkins**. From a safety side, which do we put the money into?

Mr. **Rodney**. Oh, if I had to vote strictly with just absolute blinders on on safety, I would say I would spend it on the existing system because that's the one I have to live with for the next several years, regardless of anything else. I want to keep improving it. We are putting people onboard that monitor every couple of months now, and I want to get it as safe as I possibly can.

Mr. **Perkins**. That seems logical to me, Mr. Rodney. But I wonder in terms of the process itself, what types of developments and techniques and changes—you mentioned some, I think—are going to be necessary over the course of the next 40 to 50 flights to ensure that the RSRM operates as safely as possible?

Mr. **Rodney**. Well, we have some items—for instance, the famous O-rings. I would like to see us keep trying to develop an O-ring that would be resilient under a wider range of temperatures so we didn't have to rely on the heaters.

We have some aspects of the way we assemble the nozzle now that is difficult to inspect and there may be ways of doing a better job there.

Mr. **Perkins**. Let's just hold it one second. You say they are difficult to inspect. What are the problems of inspection presently?

Mr. **Rodney**. Well, it is inherent in the non-metallic structure. The nozzle is made up of non-metallic elements, and to determine whether the bond lines between those elements are good is an extremely challenging problem to the nondestructive evaluation community. And we have only limited capability at present to verify some of those joints.

Mr. **Perkins**. What would be the effect if those bond lines aren't working properly?

Mr. **Rodney**. Number one, what we do today is, we have very strict process control. In most cases, we have redundant features in the design to back the issue up. However, we could still get a higher degree of reliability of safety if we had some NDC technique.

Mr. **Perkins**. Explain to me the specific risks.

Mr. **Rodney**. It is like many other issues where you have—these are primary elements of the motor. If they fail, you have a high chance of having catastrophic failure. That's the bottom line.

Mr. **Perkins**. You said there were redundant features. What are the redundant features?

Mr. **Rodney**. If the first layer leaks, we have the O-rings in the nozzle that would back it up, things of this nature. Now, this is not true in every case. In some areas, there are single point failures.

Mr. **Perkins**. What you're telling us at this stage, that you could have a single point failure with these bond lines which we can't inspect adequately presently that would cause basically a catastrophe, but the only type of control we have is in the process of manufacture.

Mr. **Rodney**. That is correct. I might add that we've had long experience doing this. This is nothing new. Like you fly commercial airplanes with bonded structure that have, in a sense, the same type of problem. It's very difficult to inspect some of that material.

Mr. **Perkins**. What other areas are there that we presently have a lack of ability to do an inspection on?

Mr. **Rodney**. Well, it depends. We have a variety of places where we have limited inspection capability, like the tiles on the orbiter. We have a limited capability to inspect those. What we really do on those is to run what is essentially a pull test on the item, and what we do while we're assembling it, we work coupons that are similar to the particular item that we're bonding and then we test the coupons. But we can't fully test the all-up element.

Mr. **Perkins**. Understanding that you're cognizant of the problem that you're having with the bond lines and these other areas, which would you rank as those most potentially troublesome to the safety of a mission?

Mr. **Rodney**. Well, right now, some of the bond lines in the Solid Rocket Motor would be my favorite target, yes.

Mr. **Perkins**. I am certainly concerned, as I'm sure the other members of the subcommittee are, in these areas. Again, I would agree with your prioritization at this time.

Mr. **Rodney**. See, one of the things that an ASRM might do is eliminate some of the parts. The present design, which is very similar I might add to many other Solid Rocket Motors that are flying today, is made up of an awful lot of small parts. I think we're smart enough now to eliminate part count or reduce the part count significantly, which in essence would help some of the problem.

So there are many benefits you can get through going to a new design now with all the years of experience that we've had.

Mr. **Volkmer**. Would the gentleman yield on that?

Mr. **Perkins**. I would certainly yield to my friend, Mr. Volkmer.

Mr. **Volkmer**. Definitely we would eliminate a number of joints, would we not?

Mr. **Rodney**. Yes, sir.

Mr. **Volkmer**. Where we've had the problem.

Mr. **Rodney**. Right.

Mr. **Perkins**. I thank you, Mr. Rodney and yield the balance of my time.

Mr. **Nelson**. Mr. Schiff.

Mr. **Schiff**. Thank you, Mr. Chairman.

Mr. Rodney, let me introduce myself. My name is Steven Schiff. I'm a new Member of the Congress and this committee and subcommittee, from the State of New Mexico. There are a couple of things I'd like to ask.

You mentioned, in answering another question, you described yourself as an old safety man. I am, too. I was Ground Safety Officer in the New Mexico Air National Guard for about six years so I know something about the field. Mostly what I know is the effectiveness of the safety and quality control is based upon command support. In other words if the commander, from the top commander to the line supervisors, tell their troops that we do something—if you don't mind my using the "we"—we do something useful, we get their attention. If they tell their troops, here come the pain-in-the-rears again when we come by, then nothing is going to get done.

Do you feel you have that command and support from the top management of NASA and down on through the supervisory chain?

Mr. RODNEY. Yes, I really do. As you may or may not be aware, I am not a long-term NASA employee. I've been with them about two years now. And I have had very excellent support throughout NASA. Dr. Fletcher, Dale Myers, Dick Truly, they have all been highly supportive. I've never asked them anything that I have not gotten a very positive reaction from them.

The Center directors are all very safety-conscious. In fact, we had an interesting—a lot of people talk about schedule pressure and things of this nature. The recent incident we had on this last flight where we changed out the high-pressure fuel pump, that was a program decision. It was not a very risky—we were fairly confident those pumps were good that were on the bird and, in fact, since we took them off and tore them down, we verified the fact that they were good. But there was some risk involved.

And the program made that decision even though it was very much of a scheduled risk and in fact it was a schedule risk that could very easily have affected the entire manifest. And yet that pervasive thought of safety first is well entrenched in the NASA management chains.

Mr. SCHIFF. And I assume that if you have to see Dr. Fletcher, you have that access if push come to shove on that.

Mr. RODNEY. I have never had the slightest trouble at all in accessing Dr. Fletcher. And he accesses me quite a little bit also, I might add.

Mr. SCHIFF. Two specifics if I may. I've heard it stated from those associated with the committee before I got here that there was a feeling that contracts written with contractors did not have adequate incentives for safety and quality assurance.

Do you agree with that? Was that a problem in the past and, if so, what has been done about that?

Mr. RODNEY. I believe that is generally true, and we have been taking positive action in that regard. Most of the major shuttle contracts now have positive safety quality incentives in their award fee. In other words, approximately 25 percent of their award fee is dedicated to safety and quality objectives.

Mr. SCHIFF. Can you give me an example of what would be an incentive in a contract?

Mr. RODNEY. The number of Material Review Board actions, how many items of discrepant hardware; in other words, where Manufacturing has built a hardware that doesn't meet a spec and that we have been forced to buy off, either by repairing it or using it as is. The amount of those MRBs would be a typical criteria.

Mr. SCHIFF. Speaking of hardware, I think now I'm referring to the national news, and this may be accurate, it may be inaccurate—shocking as though I know that statement might be. But I have heard about bolts, I believe it is, being sold to NASA presumably for use in the Shuttle program which are counterfeit, and I assume that that meant were made sub-specifications.

Is that a situation that NASA has confronted recently?

Mr. RODNEY. Yes. That is an industry-wide problem. It's one that you could have read about in the New York Times also, among other places. I mean it has been widely, widely publicized.

There has been some counterfeiting but it's predominantly the fact that manufacturers have not been fully certifying the bolts as required by the specification. And, in fact, there have been several legal cases in which in one company the president, I think, was sent to prison and his company was dissolved. Another company, several of the principal officers are under indictment.

There has been widespread problem in this regard, but it doesn't affect just NASA; it affects the whole industry.

Mr. SCHIFF. What, if anything, is NASA doing then to make sure as much as possible that bolts, which I take it are sub-specification, stay out of the NASA program?

Mr. RODNEY. First of all, while we have found a few that have had minor discrepancies from the specification, we have found no bolts that would be catastrophically bad; in other words, that they would probably have failed.

However, we have inventoried our entire stock. We have researched our vehicles to make sure that we don't have any of the suspect ones, and we have put out a series of guidelines instructing our people on how to keep this from happening again.

Now, the long-term solution to this, however, is to get a more disciplined supply program going and that is something we are also working on.

Mr. SCHIFF. Thank you very much, Mr. Chairman. I yield back any time I have remaining.

Mr. NELSON. Since I don't keep time, you don't have any time to yield back. [Laughter.]

General Slay did a critical items list, and his committee concluded that about 2,500 Category I and I-R components should be listed on a priority based on their probability of failure.

What has NASA done?

Mr. RODNEY. We have been characterizing CILs, rating them in a subjective manner in regards to likelihood of failure and the criticality of failure. And we have assigned values to these critical item lists by each element.

Mr. NELSON. For the Space Shuttle?

Mr. RODNEY. For the Space Shuttle. However, the granularity of the rating system we used is not as good as I would like to see it. It has ended up with too many of the things being of a highly critical but very unlikely nature, and we continue to work.

So we have been reacting to General Slay's remarks, but we still need some more work done.

Mr. NELSON. Well, this was in the post-Challenger evaluation back in March of '88, and we still haven't seen that list. So if you have it, we certainly need it.

Mr. RODNEY. All right. We will provide those to you.

[The information follows:]

SRM TOP 20 CILs

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RANK	FMEA/CIL #	LRU	FAILURE MODE
1	10-01-01-05/01	STIFFENER SEGMENTS	STRUCTURAL
2	10-02-01-02R/01	THROAT INLET HOUSING	THERMAL
3	10-02-01-04R/01	FWD EXIT CONE	THERMAL
4	10-02-01-05R/01	AFT EXIT CONE SHELL	THERMAL
5	10-02-01-09R/01	NOSE INLET/FWD END RING	STRUCTURAL
6	10-03-02-13/01	BARRIER BOOSTER ASSEMBLY	LEAKAGE L/U - ROTOR
7	10-03-04-07/01	IGNITER/ADAPTER JOINT	LEAKAGE COMPRESSION
8	10-03-04-12/01	IGNITER/ADAPTER JOINT	LEAKAGE I-GASKET/STAT
9	10-04-01-01/01	GROUND/SYSTEM TUNNEL	GROUNDING
10	10-04-01-03/01	GROUND/NOZZLE STRAP	GROUNDING
11	10-05-01-01R/01	FIELD JOINT	STRUCTURAL
12	10-05-02-11R/01	CASE/NOZZLE JOINT	LEAKAGE O-RING/O-RING
13	10-05-03-05/01	CASE/ADAPTER JOINT	LEAKAGE GASK/GASK
14	10-05-01-02R/01	FIELD JOINT	LEAKAGE INSULATION
15	10-02-03-01/02	FLEX BEARING ASSEMBLY	TORQUE MOVEMENT
16	10-05-02-02R/01	CASE/NOZZLE JOINT	THERMAL

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RANK	FMEA/CIL #	LRU	FAILURE MODE
17	10-01-02-03R/02	INSULATION	STRUCTURAL
18	10-02-01-06R/01	FLEX BOOT/COWL/INSULATION	THERMAL
19	10-02-01-27R/02	THROAT INLET/FWD EXIT CONE	THERMAL SEALANT
20	10-02-03-01/03	FLEX BEARING ASSEMBLY	LEAKAGE

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ET TOP 20 CILs

RANK	LRU	FAILURE MODE
1	LH2 FEEDLINE, EXTERNAL	LEAKAGE
2	LH2 RECIRCULATION LINE	LEAKAGE
3	STRUT ASSEMBLY (INTERTANK)	FAILS TO PROVIDE PIVOTAL SUPPORT
4	LO2 FEEDLINE, AFT ELBOW	LEAKAGE
5	LO2 FEEDLINE, AFT FLEX ASSEMBLY	LEAKAGE
6	FORWARD FLEX LINE	LEAKAGE
7	LO2 FEEDLINE, FWD ELBOW (INTERTANK PENETRATION)	LEAKAGE
8	LO2 FEEDLINE, AFT STRAIGHT	LEAKAGE
9	LO2 FEEDLINE, MID-AFT STRAIGHT	LEAKAGE
10	LO2 FEEDLINE, FORWARD STRAIGHT	LEAKAGE
11	AFT FLEXLINE	LEAKAGE
12	LO2 FEEDLINE, MID-FWD STRAIGHT	LEAKAGE
13	UPPER LINE ASSEMBLY (FLEX)	LEAKAGE
14	MID LINE ASSEMBLY (FLEX)	LEAKAGE
15	MID LINE ASSEMBLY	LEAKAGE
16	NAFLEX SEAL (P/N 55L6-1S)	LEAKAGE

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ET TOP 20 CILs

RANK	LRU	FAILURE MODE
17	LO2 FEEDLINE INSTL (P/N 80921011009-019)	FAILURE TO MEET LO2 CLEANLINESS SPEC
18	NAFLEX SEAL (P/N 55L6-5T)	LEAKAGE
19	SUCTION FITTING	FAILURE TO MEET LO2 CLEANLINESS SPEC
20	LO2 FEEDLINE INSTL (P/N 80921011913-029)	FAILURE TO MEET LO2 CLEANLINESS SPEC

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SSME TOP 25 CILs USING TIE BREAKER

RANK	CIL NUMBER	LRU	FAILURE MODE
1	A150-01	HEAT EXCHANGER	COIL FRACTURE/LEAKAGE
2	B200-04	HIGH PRESSURE FUEL TURBOPUMP	STRUCTURE FAILURE OF TURBINE BLADES
3	A600-04	FUEL PREBURNER	NON-UNIFORMITY OF FUEL FLOW IN THE INJECTION ELEMENT OCCURS
4	D110-01	MAIN FUEL VALVE	INTERNAL LEAKAGE
5	A340-02	NOZZLE ASSEMBLY	EXTERNAL RUPTURE
6	B200-15	HIGH PRESSURE FUEL TURBOPUMP	LOSS OF SUPPORT OR POSITION CONTROL
7	B400-03	HIGH PRESSURE OXIDIZER TURBOPUMP	TURBINE BLADE STRUCTURAL FAILURE
8	B400-07	HIGH PRESSURE OXIDIZER TURBOPUMP	FAILURE TO TRANSMIT TORQUE
9	B400-22	HIGH PRESSURE OXIDIZER TURBOPUMP	PUMP PIECE PART STRUCTURAL FAILURE
10	B600-06	LOW PRESSURE FUEL TURBOPUMP	FUEL LEAKAGE PAST LIFT-OFF SEAL
11	A200-09	MAIN INJECTOR	INTERPROPELLANT PLATE CRACKS
12	A330-02	MAIN COMBUSTION CHAMBER	FUEL LEAKS INTO THE CLOSED CAVITY BETWEEN THE LINER AND STRUCTURAL JACKET
13	D500-06	GOX CONTROL VALVE	MAINTAIN STRUCTURAL INTEGRITY
14	K103-01	LPFTP TURBINE DISCHARGE DUCT	FAILS TO CONTAIN HYDROGEN

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SSME TOP 25 CILs USING TIE BREAKER

RANK	CIL NUMBER	LRU	FAILURE MODE
15	B400-14	HIGH PRESSURE OXIDIZER TURBOPUMP	LOSS OF AXIAL BALANCING FORCE
16	C200-11	PCA (EMERGENCY PNEUMATIC SHUTDOWN)	FAILURE TO SUPPLY HELIUM PRESSURANT
17	E150-14	CHAMBER COOLANT VĀLVE ACTUATOR	SEQUENCE VALVE LEAKS PASSING EARLY CONTROL PRESSURANT DOWNSTREAM
18	B800-06	LOW PRESSURE OXIDIZER TURBOPUMP	LOSS OF SUPPORT AND POSITION CONTROL
19	B400-23	HIGH PRESSURE OXIDIZER TURBOPUMP	TURBINE PIECE PART STRUCTURAL FAILURE
20	B400-13	HIGH PRESSURE OXIDIZER TURBOPUMP	LOSS OF SUPPORT, POSITION CONTROL, OR ROTORDYNAMIC STABILITY
21	B400-20	HIGH PRESSURE OXIDIZER TURBOPUMP	LOSS OF COOLANT TO FIRST- AND SECOND-STAGE TURBINE BLADES
22	D300-03	ANTI-FLOOD VALVE	LOX FLOW RESTRICTED OR SHUT OFF
23	B200-16	HIGH PRESSURE FUEL TURBOPUMP	LOSS OF COOLANT FLOW TO TURBINE BEARINGS
24	B200-17	HIGH PRESSURE FUEL TURBOPUMP	LOSS OF COOLANT FLOW TO TURBINE DISCS
25	B400-18	HIGH PRESSURE OXIDIZER TURBOPUMP	LOSS OF COOLANT BEARINGS

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SRB TOP 20 CILs

RANK	FMEA/CIL #	LRU
1	20-02-10-A02	MANUAL BYPASS AND LOCK VALVE ASSEMBLY
2	50-04-X02-A07, A08	SRB OF WATERTIGHT REUSABLE CABLE
3	50-04-X02-A09, A10	SRB OF WATERTIGHT REUSABLE CABLE
4	50-04-X02-A11, A12	SRB OF WATERTIGHT REUSABLE CABLE
5	20-02-09-A01	POWER SPOOL AND BUSHING ASSEMBLY
6	30-01-06-A04	FORWARD BOOSTER SEPARATION MOTOR (BSM)
7	30-01-08-A01	AEROHEAT SHIELD (AHS) (FORWARD BSM)
8	30-01-05-A02	CDF INITIATOR
9	30-02-05-A02	CDF INITIATOR
10	30-04-01B-A01	AFT SEPARATION BOLT
11	40-01-08-A02	NOSE CAP THRUSTER
12	60-04-03-A02	FRANGIBLE NUT
13	20-02-13-A02	SEALS AND SAMPLING VALVE
14	30-01-06-A06	FORWARD BOOSTER SEPERATION MOTOR (BSM)
15	30-02-06-A05	AFT BOOSTER SEPERATION MOTOR (BSM)

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SRB TOP 20 CILs

RANK	FMEA/CIL #	LRU
16	50-02-01-04-A14	FORWARD OF MDM - PART OF INTEGRATED ELECTRONIC ASSEMBLY
17	50-04-X02-A15	SRB OF WATERTIGHT REUSABLE CABLE
18	50-04-X13-A09	SRB OF WATERTIGHT REUSABLE CABLE
19	50-04-X13-A16	SRB OF THROWAWAY CABLE AND WATERTIGHT REUSABLE CABLE
20	50-04-X13-A17	SRB OF WATERTIGHT REUSABLE CABLE

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ORBITER TOP 20 CILs

RANK	SUBSYSTEM/COMPONENT	FAILURE MODE
1	AUXILIARY POWER UNIT - CARBON FACE SEAL	CRACKED SEAL - LEAKAGE
2	MAIN PROPULSION SYSTEM - GOX FLOW CONTROL VALVE	EXTERNAL LEAKAGE
3	AUXILIARY POWER UNIT	GAS GEN EXTERNAL LEAKAGE
4	APU CONTROLLER - LOSS OF OVERSPEED CONTROL	LACK OF CONTAINMENT
5	MAIN PROPULSION SYSTEM - HELIUM REGULATOR	FAIL OPEN/STRUCTURAL OVERPRESSURIZATION
6	TPS BURN THROUGH - WING ELEVON COVE	STRUCTURAL FAILURE
7	TPS BURN THROUGH - CHIN AREA	STRUCTURAL FAILURE
8	MAIN PROPULSION SYSTEM	FAILS TO CLOSE - RUPTURE DISCONNECT - LO2 OVERBOARD BLEED VALVE
9	MAIN PROPULSION SYSTEM	LO2,LH2 PREVALVES - FAILS TO REMAIN OPEN
10	MAIN PROPULSION SYSTEM - OUTBOARD FILL/DRAIN	FAIL TO REMAIN OPEN, FAIL TO OPEN, EXTERNAL LEAKAGE

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ORBITER TOP 20 CILs

RANK	SUBSYSTEM/COMPONENT	FAILURE MODE
11	ET/ORBITER UMBILICAL DOOR - RETENTION RELEASE LATCH	SLIPS AT LESS THAN MINIMUM TORQUE
12	ET/UMBILICAL DOOR - DOOR DRIVE TORQUE LIMITERS	SLIPS AT LESS THAN MINIMUM TORQUE
13	LANDING/DECEL - BRAKE SKID CONTROL SERVO VALVE	FAILS OPEN - UNCOMMANDED BRAKING
14	LANDING/DECEL - BRAKE CONTROL CIRCUIT CARD	INADVERTANT OUTPUT - UNCOMMANDED BRAKING
15	REACTION CONTROL SYSTEM	HELIUM REGULATOR - FAILS CLOSED - ENTRY PROPELLANT REDLINE
16	ORBITAL MANEUVERING SYSTEM	INJECTOR/CHAMBER/NOZZLE BURN THROUGH
17	PREFLIGHT BUS DIODE	ERRONEOUS/INADVERTANT OUTPUT
18	EXTRAVEHICULAR MOBILE UNIT	WAIST BEARING SEAL - LOSS OF PRESSURE
19	EMERGENCY CREW ESCAPE - PARACHUTE SYSTEM	FAILURE TO INFLATE
20	REMOTE MANIPULATOR SYSTEM - JOINT RUNAWAY	DAMAGE TO ORBITER CRITICAL SYSTEMS

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Mr. **Nelson**. Is there some reason that you haven't sent it?

Mr. **Rodney**. No. No, not at all. In fact, the top 20 or top 25 in each program is posted in our Management Information Center.

Mr. **Nelson**. So you basically agree with the Slay recommendation and you're moving to go ahead and rate all of those. But out of 2,500, you have 25 done?

Mr. **Rodney**. No, no. We've prioritized, we've asked them to pinpoint the top 20 or 25 in each program. And we are really concentrating on those top ones and correlating all the failure histories and all the data we can to make sure that we fully understand those.

Mr. **Nelson**. Well, give me an example of some of them in the top 25. What are we talking about? Are we talking about a whole system?

Mr. **Rodney**. No, no. The SSME, for instance, the heat exchanger which I believe you are familiar with.

Mr. **Nelson**. So it's in the top 25?

Mr. **Rodney**. Yes, that's right.

Mr. **Nelson**. Okay. So you agree with the theory that there ought to be a listing in importance according to their probability of failure, instead of saying these are all Crit. I or Crit. I-R.

Mr. **Rodney**. On the other hand, we have to be careful of how you interpret this. One of the purposes of the CIL is to provide a guideline to all the operational folks—the quality people, the test people, the line support people, even the flight crews, as to which items they should pay special attention to.

Now, what is important, say, to the inspector to the factory may not have the same—has no significance to the flight crew perhaps, but the one that is significant to the flight crew is not significant to the guy in the factory. So you have to be a little careful how you try to shred these things out. It's not quite as simple as it would sound.

Mr. **Nelson**. Mr. Skaggs.

Mr. **Skaggs**. Thank you, Mr. Chairman.

I apologize to the witnesses for not being here for your prepared remarks. I'm thinking, Mr. Chairman, since I have been reminded by my colleague from Missouri that I cut him off on the 14th Street Bridge this morning, perhaps I should yield to him now since I didn't yield to him on the highway.

Mr. Volkmer, do you have any questions you'd like to ask?

Mr. **Volkmer**. Go ahead. I can do mine later. I've got some more time.

Mr. **Skaggs**. Sorry for the personal diversion.

I'm curious, since we understand that there were some significant changes made in the launch decision process after the disaster a couple years ago, how that has worked out in the first three launches since then.

Is it getting the job done as you wished it to? Do we need to make any further revisions to the launch decision process?

Mr. **Rodney**. No. I think it has been an outstanding success. Bob Crippen has been running an exceedingly good, well disciplined process down there. It has been very thorough. As I say, it's well thought out, and I think it's probably the best launch control—

well, not just launch because it covers the whole period prior to launch, too, and the preparation of the vehicle—that I have seen.

Now, as we go downstream, the system we have today is extremely people-intensive, and people-intensive at a major management level. We are going to have to modify some of the procedures as we go downstream, and I think we can.

If any of you ever have a chance to sit in one of the Flight Readiness Reviews, I would say you would be very, very impressed with the thoroughness and the discipline that is being followed.

Mr. SKAGGS. In fact, we are being invited to go down for launch. I'm wondering, Mr. Chairman, whether it would be instructive to the committee sometime to go down for that stage of the process, since we have all, I think, had a chance to see launch day and perhaps sit in on some of that process if you wouldn't mind some committee observers sometime.

Mr. RODNEY. I think it would be very impressive to you.

Mr. SKAGGS. Following up on that, I was reading a newspaper article a week or two ago about the plans that you have for further automating a lot of the flight control and, I assume, pre-launch process.

Can you tell us a little bit about the time line on that and your level of confidence that we can build into software the kind of judgments that we are now doing with live human beings?

Mr. RODNEY. We are making some very rapid progress there; in fact, a form of artificial intelligence. I don't know if any of you have been to Mission Control, but the mission controllers sit there with their displays which are just numbers, just piles and piles of numbers, and they're very confusing. What they have done is create what I understand is a relatively simple program which converts that into visual charts, which if any parameter goes out of the norm, it suddenly goes red in a visual sense, and it is far, far superior to the present system.

Mr. SKAGGS. If I can interrupt, are you basically saying that the systems are designed to facilitate human judgment calls rather than to replace them?

Mr. RODNEY. That is correct; yes. I guess the way we have been progressing, sooner or later we're going to replace human judgment, but we're not there yet. We do have ways of making it significantly easier to apply your judgment.

Now, your question about how rapidly that is going to take place, I can't answer that. We can get you answer. Admiral Truly was talking about that at lunch today, and he was saying how pleased he was with the way it was going.

Mr. SKAGGS. I realize, strictly speaking, that is not within your domain except in that it carries implications for your responsibilities and that's what I was really inviting you to comment on.

Mr. RODNEY. In fact, we're promoting that. We're promoting that same approach down at the Cape for the launch systems, and we are also applying a variation of that in the sense of trying to get people to look at test data and be able to interpret trends within the data, even though they're within the outer limits but they're showing variations from the normal trend.

Mr. **Skaggs**. Going back to my first question, we are reminded often in these hearings that you all are engaged in an inherently risky business and we can't expect to get to zero risk.

In your judgment, has the right golden mean been established in things like the refinements in the launch decision process? Is the balance struck appropriately between risk and getting on with the job, or are we too far toward one end or the other of that spectrum?

Mr. **Rodney**. I think we have a pretty good balance at this point in time. There are some people who might argue a little bit that we're a little overly conservative, but my position there is that until we at least fly 102, we're still in sort of the first flight basis because 102 is still going through major rework and what have you, and I am not about to relax anything until after we get through that first flight of 102.

Mr. **Skaggs**. Thank you, Mr. Chairman.

Mr. **Nelson**. Mr. Volkmer.

Mr. **Volkmer**. Thank you, Mr. Chairman.

Rodney, as I have listened to your answers to other questions and go back to the subject that I started out with and dwelled on for some time, it appears to me that the budget implications will have more implications or more effect on quality assurance than they will on safety. Is that an improper conclusion or not?

Mr. **Rodney**. Of course, I tie the two together. I mean quality assurance provides us with safety.

Mr. **Volkmer**. I mean you have certain safety programs.

Mr. **Rodney**. Yes. We have certain fixed safety programs and, yes, they won't——

Mr. **Volkmer**. They won't be impacted as much.

Mr. **Rodney**. Probably not because many more people and more dollars go into quality assurance on a day-to-day basis. And yes, fairly, if there is a budget crunch the quality systems are usually one of the targets that people like to try to lean on, and one of my jobs is to scream when that happens.

Mr. **Volkmer**. I agree with you.

Now, among the information we have at our place here, all of us at the table, is this NASA Safety Reporting System little statement. That has been in place now about, what, a year? Six months?

Mr. **Rodney**. About a year and a half, I believe.

Mr. **Volkmer**. About how many have we got back so far?

Mr. **Rodney**. We've gotten approximately 150 back.

Mr. **Volkmer**. You got 150. Out of those—now you may not be able to answer these questions now, and I'd like someone to take them down and you can give it to us later because we may be getting the statistics here, you may not have those offhand—out of those, you have a question on here that says where else have you reported your concern.

Mr. **Rodney**. Yes.

Mr. **Volkmer**. The gentleman from New Mexico has been involved in safety and quality assurance. Normally, the way I envision quality assurance is, or safety, either one, if I see something wrong or see something being approved and I'm a general worker, engineer, or whatever, I usually have somebody above me and I go to them and talk to them about it and tell them about it. Is that usually the way it works?

Mr. **Rodney**. That is correct. This is a supplementary system.

Mr. **Volkmer**. That's what I'm asking you. If it works that way and then that person then takes it on, it's taken care of one way or the other. Why do you get these?

Mr. **Rodney**. This, as I say, it's an escape valve. If a person feels that he's reported something and he can't see that anything has happened, and for one reason or another he's reluctant to talk to his supervisor or whoever, this gives him an opportunity——

Mr. **Volkmer**. In other words he feels maybe, if I can interject, that he hasn't had a follow-up, nothing has happened maybe?

Mr. **Rodney**. Yes. In fact, a clear number of them are of that nature, people working industrial safety things, they don't have an adequate platform, or they don't have adequate lighting in their work area. Well, they put in the normal chits to the facilities people and nothing happens, so out of sheer frustration, I guess, they will go to this form.

Mr. **Volkmer**. All right. Now, you've got this. Is this in your office or is this someplace else? Who does this eventually end up with?

Mr. **Rodney**. This eventually ends up in our operation.

Mr. **Volkmer**. What do you do with it?

Mr. **Rodney**. We make sure that there's corrective action and follow-up. So it's a closed loop.

Mr. **Volkmer**. Without getting into particulars as to individual items—these are just kind of categories—one category, of those that you've received, approximately how many of them had the corrective action been taken when you went back and checked on it?

I'd like to have that. You don't have to give it to me now.

Mr. **Rodney**. I don't have that today.

Mr. **Volkmer**. I would like to have that, though. In other words perhaps, the person just got a little bit in a hurry.

Then the next question I have is, those that requested action maybe that should have been done and wasn't done. How many of those? I'd like to know those.

Mr. **Rodney**. All right.

Mr. **Volkmer**. You understand?

Mr. **Rodney**. Yes.

Mr. **Volkmer**. And then what have you done to follow up, because if they weren't done, why weren't they done? You understand what I'm saying?

Mr. **Rodney**. Yes.

Mr. **Volkmer**. If you think they should have been done, then they should have been done without the person ever writing this.

[The information follows:]

The NSA Safety Reporting System (NSRS) has received 141 reports. There were 12 reports which included non-safety issues and unfounded crank complaints. No action was assigned since these kinds of communications were considered outside the NSRS scope of work. Action was assigned to 129 reports. Thirty-one reports remain open and are generally categorized as requiring longer term solutions. Of these 20 are are NSTS related; however, none of the open issues are flight safety critical. All NSRS reports are reviewed and status is reported at the Launch Readiness Reviews, if they have flight safety significance. Most issues were initially reported through normal safety or management channels and the status of the process of resolution may have been unknown by the reporter. Some were being hampered by budgetary consideration, procurement delays, scheduled implementation, etc. The reporters are aware that a NSRS report generally brings management emphasis to expedite an individual issue. A statistical breakdown of the reports reveals that 64 percent of the reports had been reported to the immediate supervisor, safety office or at formal program reviews. Twenty-five percent were reported only to the NSRS and 11 percent of the reports did not mention if the reporters had previously talked to others about the issue.

Mr. RODNEY. Of the 150 that we have received, only 20 of them are currently open and they are all in process.

Mr. VOLKMER. I agree with that, that they would be processed. I hope they would be.

Is this in use throughout NASA and the contractors, or just at NASA, or the main offices, or what?

Mr. RODNEY. On the Shuttle, it is throughout NASA. In other words, the four NASA Manned Flight Centers and their major contractors. We are in the process of implementing it in the other Centers and on the Space Station.

Mr. VOLKMER. All right.

Now, I notice on here, on the two forms that I have been furnished a copy of, it says that this part at the top here, this identification strip, is going to be ripped off and sent back to him. Do you make any record at all of the person who sent that in?

Mr. RODNEY. No. This is the secret, the anonymity. I always have trouble with that word.

Mr. VOLKMER. Keeps it anonymous.

Mr. RODNEY. Yes, it keeps it anonymous. Thank you.

Battelle Institute who runs the system for us and who incidentally runs the system for the FAA which is a similar system, they pull that tab off and they are the only ones that have ever seen the name of the submitter. We in NASA don't ever see the name of the submitter, and we have no way of accessing that part of it. In fact, they destroy their record after 24 hours.

Mr. VOLKMER. Also, I would like to have on the data that you're going to get, how many of them were concerned with items—I guess all of them would pertain to safety, though, would they not?

Mr. RODNEY. No, not necessarily. We have some random issues that come up.

Mr. VOLKMER. Various other issues, other than safety, but predominantly safety?

Mr. RODNEY. They're predominantly safety, obviously.

Mr. VOLKMER. Some with quality? Ways to do things better or something like that?

Mr. RODNEY. And we have a few crank ones, but very few, which I am thankful to say. But we have had a few that just are not even appropriate.

Mr. VOLKMER. Okay. Do you feel that it's a worthwhile program?

Mr. RODNEY. Yes, sir. We tried it over a year, and while it's difficult to work the cost-effectiveness of it, but it does provide you with a safety valve so that sooner or later somebody will probably surface a problem that will keep us from really a major catastrophe. We've had about five or six on the Shuttle which, as I say, were not in themselves catastrophic but they were items that needed to be worked. And we might or might not have found them subsequently, but we found them by this method.

Mr. **Volkmer**. By this method?

Mr. **Rodney**. Yes, we found them by this method.

Mr. **Volkmer**. See, then that concerns me. Doesn't that concern you?

Mr. **Rodney**. Yes, sir; it does.

Mr. **Volkmer**. That they had to go to this method to get to there?

Mr. **Rodney**. That's right.

Mr. **Volkmer**. Shouldn't that have been taking place without this ever being considered?

Mr. **Rodney**. But, on the other hand, as I say, the number of them has been reassuring. I think that it says that our basic systems are working and in all the cases it was questionable why the people hadn't reported them through normal channels. It wasn't obvious why they hadn't.

You always have the trouble with something like this of people saying, well, heck, I'll use this system instead of the standard system.

Mr. **Volkmer**. In other words, you had some that were reported directly without going through any channels at all.

Mr. **Rodney**. Yes, I believe that—well, as far as we know. As far as we know.

Mr. **Volkmer**. I mean as far as the check was concerned, it was checked that way.

Mr. **Rodney**. Yes.

Mr. **Volkmer**. See, I was assuming that everybody had put down that they had already notified their immediate supervisor or somebody and then got nothing done and sent it off, but you have people that didn't bother to do that.

Okay. Thank you very much, Mr. Chairman.

Mr. **Nelson**. Mr. Smith.

Mr. **Lamar Smith** of Texas. Thank you, Mr. Chairman.

Mr. Rodney, I have one question for you. That is, that over the past several years there have been varying estimates as to the reliability of the Space Shuttle.

My question is, what is your personal estimate of the reliability of the Space Shuttle? In other words, how many successful flights are we going to have before we might have an accident or have a slip-up?

Mr. **Rodney**. That's a popular question and one that I am always reluctant to answer because the people who make a profession of statistical analysis, you can, using essentially the same data, get answers that you'll see—and I'm sure you're confused because you've seen numbers probably as low as 1 in 25 and numbers that are up well into the hundreds. It's all by people purportedly using the same data.

We have run analysis as part of the Galileo environmental impact statement in which we showed a 1 in 168 as a probability number. And you will see all sorts of variations of that number. To me it doesn't—that particular bottom line number does nothing for me. Every flight is an individual gut-rending decision as to whether we are ready to fly. Every flight is a little different. The fact that somebody says it's 1 in 30 or 1 in 1,500 doesn't make the decision any easier.

Mr. SMITH of Texas. I understand that. So let me ask the question a different way. And just refresh my memory if you will. How many successful flights of the Shuttle have there been?

Mr. RODNEY. Well, there were 25 plus three.

Mr. SMITH of Texas. Twenty-eight.

And on how many of those flights have lives either been lost or endangered?

Mr. RODNEY. Well, the one unsuccessful flight.

Mr. SMITH of Texas. And then the recent one, I don't know if you consider that to be where lives were endangered or not.

Mr. RODNEY. No. On the last three flights, we have had no endangerment at all. These have been about as nominal a flight as we can ever hope to get.

Mr. SMITH of Texas. Given the fact that accidents are perhaps inevitable, though one would hope not, do you ever think that it would be wise to use the Space Shuttle for missions that were not manned?

Mr. RODNEY. You mean an unmanned variant of the Shuttle?

Mr. SMITH of Texas. Well, use the Space Shuttle for missions that did not require the presence of people.

Mr. RODNEY. Oh. Well, my way of looking at the Shuttle is that it is a very essential ingredient of whether we as a nation continue to go forth into space. We don't need to rationalize whether they're all absolutely necessary to be manned or not, I don't believe. I don't think that is a necessary criteria.

We need to develop a reliable system that we can use for manned exploration. And one of the reasons you get reliability is multiple use of the system, get experience and what have you. I don't think the fact that the payload absolutely needs a man or doesn't need a man is relevant. We need to build up that experience.

That's a personal opinion. I don't know if that's even the Agency's opinion on that subject.

Mr. SMITH of Texas. Mr. Chairman, I don't have any other questions. Thank you.

Mr. NELSON. I want to ask you about the life boat, the crew rescue system. Tell us about that. This is for the Space Station.

Mr. RODNEY. Yes, sir. That is obviously a singular concern to the safety community. We are positive in the requirement that we need a crew rescue capability. It can take many forms, as you have probably heard many of the proposals that have been offered. Those are being studied. From a pure safety point of view, what I want is the most simple system that I can get, one that can get the whole crew down, not necessarily in one package. In fact, in some sense it would be more desirable to have it in two, at least two, so that you have some redundancy and some operational flexibility.

The other issue that I have worked, and I am not absolutely firm in the thought that it needs to be available on the first manned occupancy, but we do need it and we are remiss if we don't incorporate a crew rescue capability. It's a hard decision, I might add.

Mr. NELSON. This committee certainly supports the life boat and we think it's going to be very necessary. And we're getting a little concerned that time is marching on, and you've got to have lead time. You've got to have how many years to get this thing designed and then actually up there?

Mr. **Rodney**. Probably three, four, five years. I don't have a good number. It depends on the system. That's one of the reasons I want a simple system.

Mr. **Nelson**. Well, it's right about that time, right now.

Mr. **Rodney**. Yes. It's coming close.

Mr. **Nelson**. Any further questions from the committee?

Yes, sir. Mr. Rohrabacher.

Mr. **Rohrabacher**. Mr. Chairman, thank you.

About the life boat question. I asked you costs earlier, and I would like to ask this and this deals with costs as well. Do we have any cost estimates on the life boat?

Mr. **Nelson**. We should get that from Admiral Truly.

Mr. **Rodney**. Yes. Admiral Truly's organization is working the trade studies of the various options and what the cost factors are. I'm conversant with the technical details. I haven't spent a lot of time looking at the costs.

Mr. **Rohrabacher**. If these costs for the life boat would be more than the Space Shuttle itself, don't you think perhaps we could just park a Space Shuttle up there if that's going to be the cheapest method?

Mr. **Rodney**. Well, now wait a while. I hope that the costs aren't like the Space Shuttle costs or we're in trouble.

Mr. **Rohrabacher**. What I'm saying is, at the very least we've got a Space Shuttle. If we want to have an emergency system, at the very least we could have a Space Shuttle if it would cost less than that.

Mr. **Rodney**. No.

Mr. **Nelson**. You just simply can't park a Shuttle up there.

Mr. **Rodney**. Unfortunately, a Shuttle isn't designed to be parked. It gets very, very useless at the outside of two weeks.

Mr. **Nelson**. You know, your question points out if we had another accident and you have a crew up there and you need to get to them and you don't have the launch capability to get up there with a Shuttle, the question is: how do they get home?

Or, suppose there's some emergency on board the Space Station and suppose there's a hurricane in the Atlantic Ocean and you can't launch because of something completely unconnected with the viability of your launch system, but you've got an emergency up there and folks have to get back.

That's why it makes sense to have what we've been referring to as a life boat. And it could be a blade of heat shield technology. I mean it wouldn't have to be a vehicle which would come and land on a runway like the Shuttle.

Any further questions from the members?

Well, thank you, Mr. Rodney. You stay vigilant. Thank you very much.

[Whereupon, at 3:10 p.m. the hearing was adjourned.]

1990 NASA AUTHORIZATION

THURSDAY, MARCH 23, 1989

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, DC.

The subcommittee met at 9:40 a.m., in Room 2325, Rayburn House Office Building, Hon. Bill Nelson, chairman of the subcommittee, presiding.

Present: Representatives Nelson, McMillen, Nagle, Skaggs, Sensenbrenner, Lewis, Packard, Buechner, Rohrabacher, Morella and Schiff.

Mr. NELSON. Good morning.

This is probably the last appearance as administrator for Dr. Fletcher, and this committee wants to take the opportunity, and I do personally, Dr. Fletcher, to thank you for your leadership of the Nation's space program at a very trying time, one that it was difficult for you personally, it was difficult for NASA as an institution. It was constantly a game of catchup. But indeed you have caught up, and you have helped put America back where she rightfully belongs, and that is reclaiming the high ground and back in our rightful position in space.

We want to congratulate you with the team that you have assembled. I had the privilege of being the nominator for the winning nomination of the Goddard Trophy this year. And I nominated the team that you put together. Indeed it was the team that returned America to space, led by Admiral Truly and the four center directors that played such an instrumental part.

And it is a tribute to your leadership that you could go out across this land and select people of such quality as you have in the four center directors and in Admiral Truly. And for them to work under your leadership and to do so as effectively as they have is a tribute to your leadership.

So, it is with profound gratefulness that this committee convenes today.

And I want to turn to my ranking member, Mr. Sensenbrenner.

Mr. SENSENBRENNER. Thank you very much, Mr. Chairman. I certainly wish to associate myself with the remarks of the chairman about the tremendous job that you have done, Dr. Fletcher, in bringing America's space program off the floor and back into space where it belongs.

Obviously, your second stint as NASA director was much more difficult than the first one because of the Challenger disaster and the fact that many people were asking a lot of questions about

NASA, about its administrative capabilities and about whether we really were getting our money's worth in terms of the expenditures that Congress makes.

So, I would like to salute you, to thank you on behalf of the Nation, and to wish you godspeed in your future activities, and I am certain that you will be back here giving us advice as the years go ahead, perhaps with a little different hat on.

Thank you.

Mr. NELSON. Dr. Fletcher, we had asked you to come back today because we wanted to have the NASA submittal, the legislative authorization request for carrying out the 1990 budget request. We now have it. We received it a couple of days ago.

You know, certainly within the budgetary request there are these seven commercial initiatives, so-called, and I think that one of the things that the committee is trying to do is clarify the definition of the word "commercial," that these are really more akin to private financing for budgetary reasons than they are in the true sense of space commercialization.

Therefore, what we want to do as we proceed through this—and the committee is not necessarily adverse to this—we will have quite, shall I say, a robust session.

May I invite those people standing at the door to please come in and have a seat.

[Pause.]

We want to make sure that everybody understands that in the true sense of commercialization, we do not want this to mix up what is a true space commercial enterprise.

Now, if the long and short of this is that here is $13.2 billion for a budget and you can only get so much in it, but in fact if you need these other things and we have got to figure out other ways of financing them, then what we need to do is we need to call it for what it is and that is what it is.

Now, in the interim, I have talked to the director of OMB, Mr. Darman. In essence, this is what it is. I think the conclusions of the committee will stand.

So, what I would like to do is to examine these in the light of what does NASA need, not as a justification of calling something something that we might have differences in the way of definitions, and then we can all go and figure out together how we ought to get these things financed.

I might point out that one of the things that concerns me is the experience of the TDRSS. Years ago we financed the TDRSS in a private financing kind of way, and as it came back it ended up costing us a lot more than it ever would have if we had paid for it directly.

If we have a choice, I think this committee does not want to make that kind of a mistake. On the other hand, if there simply just is not enough money to go around and yet there are things that have to be done, then we have got to be creative and innovative and figure out how to do it.

So, what we want to do is to help you in this process. So, in that spirit is what we wanted to have. We want to have you, of course, have the opportunity to share with us in the final days of your administration share with us what your ideas are, but we particularly want to zero in on that topic.

Dr. Fletcher?

STATEMENT OF DR. JAMES FLETCHER, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY DALE D. MYERS, DEPUTY ADMINISTRATOR; DR. NOEL W. HINNERS, DEPUTY ASSOCIATE ADMINISTRATOR; THOMAS CAMPBELL, COMPTROLLER; JAMES T. ROSE, ASSISTANT ADMINISTRATOR FOR COMMERCIAL PROGRAMS; DR. LENNARD A. FISK ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS; EDWARD A. FRANKLE, GENERAL COUNSEL; BILLIE J. MCGARVEY, ASSISTANT ASSOCIATE ADMINISTRATOR FOR FACILITIES MANAGEMENT, OFFICE OF MANAGEMENT; RADM RICHARD H. TRULY, ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT; JAMES R. ODOM, ASSOCIATE ADMINISTRATOR FOR SPACE STATION; AND KEN PEDERSEN, ASSOCIATE ADMINISTRATOR FOR EXTERNAL AFFAIRS

Dr. Fletcher. With your permission, we have tried to answer some of the questions you have raised, in my written testimony. If you will agree, I will submit that for the record and sort of wing it as far as responding to your questions and also some of the other questions raised in your letter.

Mr. Nelson. Let me interrupt just a second. I think it is a committee rule that I am to ask for unanimous consent for media coverage. And, without objection.

Please go ahead.

Dr. Fletcher. I would like to respond to your opening remarks about the recovery. It is true that NASA is back on track as far as the shuttle is concerned. We have flown the Discovery and have flown it again, which was part of the problem to recover quickly and on schedule. And as you properly stated, Atlantis also has been turned around on time and is on the pad in time for the Magellan launch.

As you also properly indicated, the recovery team led by Admiral Truly--and the four center directors, I might add, Arnie Aldridge, who is the level II director, program director of the shuttle program—all of these folks really were the ones who put it back together.

My responsibility was to let them do it, encourage them to do it, find the money for them to do it, and also keep the rest of NASA on track. I think we have done that, and I appreciate your mentioning that.

Also, I want to thank this committee. We got off to kind of a rocky start when I first came back, and I imagine we were all upset because of the accident. But over the ensuing months I think we have had a very good working relationship, and when it came down to the clinches, you were to help, and I do appreciate the support that you have given me personally and also NASA as a whole.

It hasn't been an easy thing, because you have increased your oversight, I think fairly. And yet, when it came to help, you were there when we needed you.

Before I address the concerns you mentioned on the commercialization initiatives, you did ask in your letter some questions about the legislation that we required. I will address that in a moment.

But let me just say that part of the problem—you hinted at it—we have this year is that we are at a make-or-break point in the Nation's space enterprise. We were cut rather severely in Congress last year, but we managed to save the space station.

We were cut about $600 million or $700 million, as I recall. It depends on how you count the transfer from DoD. And we did save the space station from slipping that year, but we cut everything else in NASA—and when I say we, the Congress—and there wasn't very much left to cut. And then we took a very hard hit from OMB in the fiscal '90 budget.

Actually, the amount that we received in fiscal '90 was less than the run-up from last year's decisions, and hardly anything for new starts; one percent, I believe. So, we really can't stand any kind of a hit again on the whole NASA program without again slipping the space station, and if we do that, as I have gone on record saying, we have slipped too many times and ought to reconsider whether we want to go ahead with the space station and also whether we ought to restructure NASA.

So, I think it is crucial not to make another run on NASA's budget. That does complicate the commercialization initiatives, as you properly pointed out.

But dealing with the new legislation, we have several items that need to be explained. The first is the requirement for FOIA, the Freedom of Information exemption relating to unclassified but controlled new technology.

Today, a company that does work for NASA cannot export certain technical data without a license, but any foreign concern can and does gain virtually instant access to that data through the exercise of FOIA.

The proposed language in section six of the bill would simply allow us to ensure that new American technology is first available to American industry. And without that protection, the taxpayers in effect subsidizing America's international high-tech competitors. We have to address that problem some way.

The second piece of legislation is a clarification of the applicability of U.S. patent laws to activities that are taking place aboard U.S. space vehicles like the shuttle, like the space station, like Spacelab, or the CDSF if it turns out that we go ahead with that.

The proposed changes would allow us to implement the international intergovernmental agreements on the space station. And so we require some sort of clarification there.

And last, we come to provisions that will allow us to encourage and in some circumstances rely upon private sector investment in space activities. We discussed that before, but Jim Rose will be testifying next month on the commercial programs, on the details. So, I will try to concentrate on the seven candidates that you indicated earlier in this hearing and that we identified during the budget formulation with OMB last year.

While each of these seven prospects is really a unique case and will continue to be, every case is different, and it is hard to come up with generic language which applies to all cases.

We should try to recognize the motivations that led to the ones that were considered for private investment. The first thing that we need to do is to encourage the private sector to increase its stake in space and to look to space as an expanding frontier of economic opportunity with a future customer base well beyond the Federal Government.

Now, you mentioned the TDRSS. That was not our first commercial venture. The first commercial venture that we tried was the communications satellite. The first was Telstar that we launched and then Syncom, Syncom I, I guess, in retrospect. And that was easy to turn over to the private sector, and we did so. In fact, that is a healthy private business at this time.

The TDRSS probably was the second, although there may have been some in between. We have always felt that when we can turn things over to the private sector, we should.

TDRSS had some problems, although the jury is still out, because the company that we dealt with had some financial problems and they were not able to make use of the private portion of that satellite.

We still are advertising the CBD for private use of the C-band antenna on the TDRSS satellites that now exist, and we may find that part of that money comes back that we lost through overruns. But nevertheless, that was a good experiment. We learned a lot from that. So, we are getting good and bad experience, and that is the nature of privatization.

But some of the other ones that ought to be mentioned is that we had a program called PAM-D. It started out with a different name, but it ended up PAM-D, which McDonnell Douglas supported with private money. It was a very successful program, and they were very close to getting their money back with the return on their investment until we decided to move communications satellites off the shuttle. The jury is still out on that one, and I think they will get their money back, but not in the original sense that it would be the primary way of launching communications satellites.

Then we moved, not on my watch but on Jim Beggs' watch, into financing private upper stages—and the TOS is a good example of that—upper stage for the shuttle. Orbital Science Corporation decided we needed an ultimate upper stage for small payload. We are going to use TOS on a number of our future payload launches, and that is going to be a successful program.

Now, there are spinoffs from that sort of thing. Orbital Science Corporation went ahead as a result of the success there and are now proposing to DARPA, I think, a new program which they call Pegasus, which is a way of launching smaller satellites, somewhat larger than the Scout. And that appears to be—and we are helping by providing the initial launch platform an aircraft out at Dryden to help them get started on that. So, you can't always tell where privatization is going to lead.

We have had some successes, and we have had some problems, and so we are learning as we go along. So, that is our first idea, first motivation.

The second point is that we want to get our job done at NASA at the least cost to the taxpayers. But it has got to be commensurate with other responsibilities for performance, safety, and security.

So, we tend to strike out things that may impact on safety. And there were some problems with the extended-duration orbiter which had to be worked out very carefully, and we are still working them out after the budget went ahead to Congress, and there are still some problems left on that, but we think we have solved the safety part of it.

And also, we want security at the enterprise. Those are constraints on whatever we decide to privatize.

Now, having said that, let me focus on the projects one at a time and try to put them in some kind of a rational context. We have been working very hard on that rationale, what should be included and what shouldn't be and what are the criteria.

First, we need an advanced solid rocket motor, as you know, for improved shuttle safety and for shuttle performance. We are in a technical competition with the ASRM, and we have allowed for the selection of a Government-owned or contractor-owned facility option. And we explained that to you last year.

The competition is about to be resolved next month. So, we are very close to a decision there. However, to make the contractor-provided facility option realistic, we need to guarantee a no-loss situation to the selected contractor in the unlikely event of program termination by the Government. And that is why we have asked not for termination of liability up front, but at least an indication from the Congress that they would provide it if needed.

The second initiative—second and third, really—we have two space station facilities: the neutral buoyancy lab at Johnson Space Center, and the space station processing facility at the Cape, which may lead themselves to being built by the private sector. I believe it is probable that there is enough non-Government demand for the NBL to reduce the Government cost for its work in the facility. And we have some evidence of that.

It may also turn out that private enterprise can build such facilities and then lease them to us at rates that legitimately defer costs to NASA.

We are studying all of the pertinent approaches and plan to issue drafts in the spring that will solicit specific industry proposals on the matter of private investments in these two facilities.

If that turns out to be the right way to proceed, we would need to offer the bidders the protection of contingent liability coverage in the event of termination. And we have expressed that to you in previous testimony.

It may turn out that they don't need that. We have asked for an indication on which ones need it and which ones don't. But most feel that they need some sort of assurance that there will be termination liability if they go ahead and win the contract.

The third thing that I want to deal with is an entirely different kind of thing. We are preparing to negotiate with Rockwell, the shuttle prime contractor, on possible private investment options for the EDO, the extended direction orbiter capability that we intend to have by the time of the first international gravity laboratory in 1991. That is the international MSL.

Now, we have a time bind on this one. We have to move ahead fast. We have a mechanism which we think does not require termination liability. We think that can be handled under the existing

Rockwell contract and we can meet the schedule and also meet the safety constraints. And that wasn't easy, but I think we're there.

This does look like a viable candidate because there are other potential users for the EDO capability, commercial users beyond those supported by the Government. So, we don't think we need termination liability, but nevertheless it is a legitimate private commercialization initiative.

The fourth category is the space station docking module. Now, that is kind of far out, so to speak—or, as somebody would say, off the wall. That had not occurred to us as being appropriate because there are safety issues involved. And while we identified it in the budget as a potential private investment project, it is not on a time-critical path. We have not done enough analysis to read the report to you on the proper direction that we should pursue, but we simply thought we ought to mention that because we are working on it. And we are not asking for termination liability on anything until we have really got things lined up a little better on the docking module.

Now, the FTS, the flight telerobotic servicer, we are in a bind. We do have a timetable which has been prescribed by the Congress at which the FTS must be available. I have forgotten the date. I think it is 1992—1991. So, we are on a fast track there. We have a competition under way. At least two contractors have submitted proposals. And we are in the process of evaluating those. So, that gets pretty complicated.

And in addition to that, it is a very high-technology program. It is an R&D-type program. And how do you privatize a very high-risk R&D-type program? At first, it seemed impossible, and then we had to look at it, and they say, well, if it is high technology, the contractor may want property rights for the support that he gets.

Telerobotics is a hot topic, and putting all of the things together we really at this point don't see how we can make that schedule and also introduce into the current competitive situation by some sort of privatization. So, at this point we do not see how to do the FTS and am hopeful that very soon the OMB will sign up to that.

Now, I am afraid that one of our problems is that if we do not privatize it, where is the money going to come from? I already said at the beginning of this testimony that there is just no room for much cutting in the fiscal '90 budget. So, if we don't privatize, the money will come out of the space station and it is the one program we don't want to have slipped again. It has slipped three times since it started in 1984. We have a problem on how to finance it. Otherwise, I think the OMB would sign up to dropping that from our commercial initiative.

Now, that kind of gives us—that fits things into different categories. Each one is in a different category. The ground facilities, we think there is a lot of optimism at NASA for dealing with those. The space facilities, EDO, we have already found a way to work with it if the Rockwell folks come up with the right kind of proposal so that it is of net advantage to the Government. They are working with the Teledyne Corporation to do that. We have worked out a mechanism which they have proposed which protects the safety of the shuttle.

And then of course there are the FTS, which I think we will back away from. But it is not quite done yet.

And then the docking module is off in the future, and we are not asking for any termination liability.

Well, that kind of summarizes and puts in sort of a rationale the different categories of commercialization. We are feeling our way here and we are trying to put forth a general policy, working with other parts of the Government on what we mean by commercialization, when does it make sense, when doesn't it make sense and so on. It turns out the more we get into it to be a very complex subject, but nevertheless we are determined—I am while I am here and I think the Administration is—to commercialize space when it is appropriate.

I have tried to give the criteria on at least these seven projects where it is appropriate. That is most of my testimony.

But let me just say again this probably is my last hearing before this committee and before Congress. And I just want to thank you for all of the support you have given me especially in the last two years when things began to come together again. And I hope you will give my successor the same sort of support. Thank you.

[Letter from Mr. Nelson and Dr. Fletcher's prepared statement follow:]

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March 16, 1989

Dr. James C. Fletcher
Administrator
National Aeronautics and
Space Administration
Washington, D.C. 20546

Dear Dr. Fletcher:

As you know, over the past several weeks, a great many questions have arisen pertaining to the FY 1990 legislative request and certain other issues affecting NASA's authorization. Accordingly, the Subcommittee on Space Science and Applications will hold another hearing to review the overall agency posture.

I would like to invite you to testify at this hearing. The hearing will be held March 23, 1989 at 9:30 a.m. in Room 2325 of the Rayburn House Office Building. I ask that you provide the Subcommittee with the Administration's legislative request prior to that date for our review.

Your testimony should address the specific authorities and general provisions that you will be requesting in the FY 1990 Authorization Bill. As a practical matter, I anticipate that the most important issue we will address is the privately financed facility projects and your request for termination liability. In order for the Committee to provide guidance to NASA, as requested in your February 22 letter, we will need to fully understand the policy objectives of these privatization proposals, including the kind of private sector arrangements you expect to seek, the estimated cost to the Government, the effect of these proposals on ongoing programs, and the criteria by which you intend to judge the acceptability of specific privatization options. In addition, in those cases where you believe there to be a likelihood of non-Government use of specific projects, please provide evidence of such likelihood, and its effect on the overall project.

I ask that you also be prepared to discuss other requests for specific authority that are contained in the proposed authorization bill such as exemptions from the Freedom of Information Act, patent law changes, and issues concerning the designation of NASA facilities as historic landmarks.

The enclosed guidelines set forth the requirements for preparing and submitting testimony. You may contact either Dr. William Smith or Ms. Susan Dumay at 225-7858 should you have any questions. I look forward to an informative and productive hearing.

Sincerely,

Bill Nelson

BILL NELSON, Chairman
Subcommittee on Space Science
and Applications

BN/Ssd

Statement of

James C. Fletcher
Administrator

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science, Space and Technology

House of Representatives

Mr. Chairman and Members of the Subcommittee:

I am pleased to appear once again before you to discuss NASA's FY 1990 legislative request. As you know, NASA's proposed FY 1990 authorization bill was transmitted to the Congress this week. As submitted, it requests a total authorization of $13.3 billion, which represents an increase of $2.4 billion above the FY 1989 appropriation. Of the total budget, only 1% is devoted to new initiatives, with the entire balance applied to ongoing activities previously approved by the Congress. The bill earmarks funding for the Space Station totalling $2.050 billion in FY 1990, $2.981 billion in FY 1991, and $3.494 billion in FY 1992. The bill also requests $11.7 billion for FY 1991 and $12.2 billion for FY 1992 to carry out the other parts of NASA's FY 1990 program.

Mr. Chairman, this is a crucial budget year for NASA, and it is critical that Congress act favorably upon this legislative request. It is my firm belief that even modest Congressional reductions in this budget proposal cannot be absorbed without once more delaying the availability of the Space Station Freedom. In consideration of the serious fiscal situation confronting the Nation, NASA's FY 1990 budget was formulated at the minimum level possible to meet the President's budget objectives. NASA needs the full support of this Committee and the Congress as a whole to keep the civil space program, and particularly Space Station Freedom, on track.

Let me now take a minute to describe three specific legislative proposals that are included with our FY 1990 authorization bill and then turn to our proposed commercialization initiatives. The first legislative proposal, contained in Section 6 of the Bill would authorize NASA to issue regulations permitting us to withhold from release under the Freedom of Information Act technical data in our possession if that data could not be exported lawfully without an export license from the Department of Commerce (if dual-use technology), or the Department of State (if munitions technology). I cannot overemphasize how important this provision is to NASA and to this country. As you know, NASA is the principal research and development agency in the United States in the areas of aeronautics and space. The work done by NASA in developing new technology is a vital part of our national effort to retain technological leadership and keep the United States economically competitive with the rest of the world. Over the past few years, however, we have become aware of an inconsistency in various parts of our laws which is hampering NASA's ability to assist domestic industry. The inconsistency exists between the export control laws which are designed to limit the off-shore flow of certain categories of valuable technical information and goods, and the Freedom of Information Act (FOIA) which is designed to insure that government operates in the sunshine. While I strongly support the basic principle of the FOIA, in the one narrow area of unclassified technology it has the unfortunate and unintended consequence of effectively nullifying U.S. taxpayer-sponsored work to develop new technology such as that involved in our high speed aeronautics research and in the Pathfinder and CSTI programs. The whole purpose of many of our programs is to develop the technology needed to maintain U.S. leadership in aeronautics and space. But because the FOIA requires that unclassified agency records be made generally available--regardless of the nationality of the requester--our ability to limit our assistance to domestic industry is destroyed unless the specific document falls within one of the very narrow exceptions to this FOIA.

Please understand, we are not trying to hide anything with this proposed legislation. We are committed and are willing to commit to insuring that new technology is disseminated domestically. But unless we have some mechanism which will give our industry a reasonable opportunity to utilize this technology first, our programs will effectively be transformed into U.S. taxpayer support for foreign governments and industries which do not similarly release their technological advances to us. In short, we need this legislation, which by the way is very similar to legislation obtained by the DoD in 1983, and we need it now. Without it the viability of our whole technology development program is in doubt.

The second piece of proposed legislation which we are requesting relates to the application of patent laws to inventions made in outer space. This legislation, which is similar to that contained in H.R. 352 and S. 459, would add certainty to the law while at the same time giving the United States the flexibility it needs to enter cooperative international agreements relating to activities in outer space.

Without going into the details of the legislation, it provides that U.S. patent laws apply to activities on board vehicles under the jurisdiction or control of the U.S. This will permit certainty as to the applicability of our patent laws in a large number of circumstances. For example it would imply that inventions made in a U.S. commercial facility such as a SPACEHAB or a CDSF would be subject to U.S. patent laws, even if the user was a foreign entity. The provision is intended to be consistent with U.S. international law obligations, including Article VIII of the Outer Space Treaty, which provides that "[a] State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body." Thus, this provision should not be interpreted to apply to a foreign-registered space object unless there is a specific agreement with the registering state in this regard. In addition, the statute provides an exemption from the normal rule allowing international agreements to provide for a different application of patent laws. This exemption is a necessary legal prerequisite for the Space Station Inter Governmental Agreement (IGA) to enter with force in one limited area.

Specifically, the proposed exception is required by the Space Station program because Article 21 of the IGA provides that each partner agrees not to apply its laws relating to secrecy of inventions so as to prevent the filing of a patent application in any other partner State. In order for the U.S. to comply with this IGA provision, the waiver of 35 USC 184 is necessary. The proposed exception would allow the IGA to be implemented. This intellectual property provision is not controversial. It has passed the House of Representatives in both 1986 and 1988 and is now pending as a piece of separate legislation in both the House and Senate. Hearings have been held and there is strong private sector support for this language. I look forward to its passage and the full entry into force of the Space Station IGA.

The final section of proposed legislation relates to our requested authority to enter into agreements for privately financed facility projects. I know that this is a topic of great interest to you and a significant portion of my testimony will address the facilities that are being proposed for their treatment. The proposed legislation and its applicability to those facilities will be discussed in the context of those concrete proposals.

Let me next address the manner in which NASA's FY 1990 legislative request is structured to encourage greater private sector investment in space and related activities. As you know, American industry has for many years been an important partner with Government in implementing U.S. civil space programs that, taken together, have produced an unsurpassed record of achievement and excellence. Indeed, the President's commercial proposals build on our strong and experienced aerospace industry base while reaching out to draw in the resources and skills of commercial sectors that heretofore have not been part of the traditional space enterprise.

The overarching objective of these commercial initiatives is embodied in U.S. National Space Policy which states that "expanding private sector investment in space by the market-driven commercial sector generates economic benefits for the Nation and supports governmental space sectors with an increasing range of space goals and services." Recently, President Bush confirmed his support for this objective and stated that as a fundamental principle of his Administration's space policy, "private sector initiatives in space should be strongly encouraged, including creation of additional research and manufacturing opportunities." As Administrator of NASA, and as a former space entrepreneur in my own right, I fully subscribe to the goal of expanding U.S. private sector participation in our nation's space program. Properly done, private sector investment in space projects can reduce Government costs with no loss in quality or performance. Of equal or even greater importance, the development of a healthy commercial space sector can contribute significantly to advancing overall U.S. technological leadership and improving our nation's economic international competitiveness. Other countries--both East and West--are actively investing in and marketing space goods and services on a global basis. After more than thirty years of undisputed leadership, we cannot afford to be anywhere but on the leading edge of the emerging space economy of the twenty-first century.

As I noted earlier, U.S. industry has been an important part of the space program from the beginning. However, the concept of the private sector investing--that is, putting capital at risk--in space-related activities is, with a few notable exceptions, a relatively new idea. For many years space operations, both in orbit and on earth, were considered the responsibility of government, with the lone but significant exception of communications satellites. While the situation is changing, the U.S. private sector has been slow to enter the space field on a commercial (as opposed to contractor) basis. There are many reasons for this, including the large costs that are often involved, the fear of government competition, the risks associated with long and uncertain payback cycles, and the lack of identified and reliable markets.

NASA is doing a number of things to improve the climate and prospects for greater commercial involvement and success in the space field. Mr. Jim Rose, who heads NASA's Office of Commercial Programs, will be testifying before you in the near future, so I will not attempt to cover the ground in any detail. I would, however, like to give you some feeling for the scope and diversity of our commercial space activities. We have now begun to procure ELV launch services from the private sector wherever these services are available on a commercial basis. We have also entered into negotiations and, in some cases, reached agreements with U.S. expendable launch vehicle operators to provide reasonable access to and use of NASA support services and facilities. These actions support the national mixed fleet strategy and actively foster the growth of a healthy domestic ELV industry capable of competing commercially worldwide.

NASA has, consistent with National Space Policy, developed and released for industry comment criteria, guidelines and procedures to assist firms interested in proposing commercial initiatives, especially those related to the future development and use of Space Station Freedom. Working with industry, we are currently refining these documents to ensure that companies can deal with NASA confidently on a predictable and timely basis.

NASA has signed an agreement with SPACEHAB, Inc. to fly that firm's privately developed module on the Space Shuttle. The SPACEHAB module increases the pressurized working space on the orbiter by 1000 cubic feet, a factor of 7 times the research space currently available in the mid-deck area, and is being marketed on a commercial basis to customers desiring man-tended microgravity exposure for their payloads. NASA has manifested SPACEHAB on five flights beginning in November 1991, and has agreed to defer payments for launch services until after each launch has occurred.

As you know, with respect to the "Commercially Developed Space Facility" (CDSF), NASA has contracted with the National Research Council (NRC) and the National Academy of Public Administration (NAPA) for the studies required by Congress last year. These are expected to be completed later this spring and should give NASA and the Congress sound guidance on how this program should proceed.

We have also solicited expressions of interest by the private sector in using expended Shuttle External Tanks (ET's) in orbit. Ten organizations responded to our Commerce Business Daily notice and three of the proposals received have been judged worthy of further technical, safety and business evaluation. These assessments are currently underway. In a related action, NASA signed an MOU with the University Corporation for Atmospheric Research permitting it to use space in up to five designated ET's for sub-orbital research during the tanks' re-entry phase.

By means of Joint Endeavor Agreements (JEA's) NASA is continuing to make its facilities and services, including flight opportunities, available free or at reduced cost to qualifying firms that are investing their resources in the development phase of space-related products. These agreements are important tools in managing the risks associated with pioneering new markets.

Finally, let me mention that through the sixteen Centers for the Commercial Development of Space (CCDS's), NASA is working closely with industry and the university community to foster early research into promising technologies and applications which someday may yield marketable goods and services. The work going on in the CCDS's today will produce the candidates for tomorrow's JEA's and, ultimately, many of our future commercial space products. The composition of the CCDS's ensures that the work will be driven by solid research and marketplace values, with NASA supplying the initial financial support necessary to moderate risk and provide confidence-building stability.

As you can see from these few examples, NASA is actively engaged in promoting and supporting commercial space activity on a broad front. I want to emphasize, however, that we do not claim to have all of the answers to what is a complex and long-term challenge. In many cases, we at NASA are in an exploratory mode. This is especially true in the area of space-related infrastructure where NASA is currently seeking to determine from the best source possible--the private sector itself--when and under what circumstances its members are prepared to invest their resources.

As you know Mr. Chairman, the President's FY 1990 budget proposed seven specific infrastructure projects as candidates for private investment. They are:

- The Advanced Solid Rocket Motor (ASRM) Facility
- The Space Station Processing Facility (SSPF)
- The Neutral Buoyancy Laboratory (NBL)
- The Observational Instruments Laboratory (OIL)
- The Space Station Flight Telerobotic Servicer (FTS)
- The Space Station Docking Module
- The Extended Duration Orbiter (EDO) kit

NASA's commitment is to pursue the potential for private investment in each of these projects. I emphasize "pursue the potential" because I feel that some have concluded that NASA has already determined that the private sector can and will invest in each project and that we are asking the Congress to endorse or approve such a determination. That is most assuredly not the case. It bears repeating that the U.S. is still in the early stages of building a commercial space industry. Outside of communications satellites, the developing expendable launch vehicle industry, and perhaps the remote sensing field, we do not have a lot of direct experience--either good or bad--to draw upon. We do have a broad set of guidelines embodied in the National Space Policy, but those guidelines, while necessary and helpful, must be implemented by laying out some specific infrastructure opportunities and seeing whether and how the private sector responds. That is what we are doing with these projects.

By design, the projects are diverse, including both terrestrial facilities and flight systems in various stages of conceptualization or acquisition. These commercial initiatives were initially selected for exploration based on: (1) previous expressions of interest from industry sources, or (2) their potential for multi-purpose (i.e. government and industry) use, or (3) their conformance with the National Space Policy which directs that agencies will seek to rely to the greatest extent feasible on the private sector for goods and services. Because of their diversity, the form and scope of prospective private sector investment will likely differ from one to the other. While we certainly intend to make a good faith, energetic effort in each case, we may not succeed in attracting acceptable commercial proposals in every instance. Yet, at this stage we stand to learn a great deal from our setbacks as well as from our successes. However, we cannot succeed and we cannot learn unless we are allowed to try.

Against this backdrop, I would like to describe four specific steps we are taking to meet our commercial objectives with respect to these infrastructure projects:

First, we are, wherever practical, already inviting private sector firms to express interest in and make specific proposals for investing private funds in these projects. For example, in the cases of the Space Station Processing Facility (SSPF) at Kennedy Space Center and the Neutral Buoyancy Laboratory (NBL) at Johnson Space Center we placed notices late last year in the Commerce Business Daily (CBD) soliciting responses from private sector firms interested in investing in these facilities. Fourteen substantive responses were received on the SSPF and six responses were received on the NBL. The nature of these responses suggests to us that there are sufficient grounds for proceeding further down the commercial path on these facilities. Accordingly, we have formed procurement development teams at the two centers and they are in the process of developing acquisition strategies which will lead to draft RFP's providing specifically for private investment. We plan to issue these draft RFP's for comment in late May or early June. Prior to release of the final RFP's we will consult closely with the Subcommittee.

In contrast to the other facilities, the ASRM formal contractor selection process is already well underway. Here, we have provided through the RFP process for the possible selection of a private investment approach while also retaining the option of a Government-financed facility.

The Extended Duration Orbiter project is even further down the track, since the prime contractor for that work has already been selected through modification of an existing contract. In this case, we have approached the prime contractor, Rockwell International, and solicited its interest in a private investment approach, probably in conjunction with another private firm, Teledyne Brown, which has already indicated a possible investment interest in the EDO system. Rockwell has indicated a desire to explore private investment options with NASA and we anticipate that discussions will begin shortly.

Second, we are seeking to ensure that private firms which are interested in pursuing investment approaches with us can come forward with confidence that the risks they assume will be reasonable and not arbitrary. In particular, it is our view that private parties will propose and provide financing for major projects, like the ground-based facilities proposed in the President's budget, only if they can be sure in advance that their investments are protected through Government assumption of liability in the event these projects are terminated by the Government for its convenience, and they are thus denied the opportunity to make normal commercial profits. To this end, we have forwarded to Congress two pieces of proposed legislative language. The first would provide NASA with liability authority to support whatever award is made following completion of the evaluation and selection process for the ASRM facility. As I indicated last fall, receiving this authority or at least a clear indication now from Congress that it would be provided promptly if needed to support the selection of a privately financed option is, in my view, vitally important. It would ensure a "level playing field" during selection and would provide for moving expeditiously forward after selection should a privately financed ASRM proposal be chosen. The second legislative initiative is contained in the Administration's proposed FY 1990 NASA authorization bill and would apply to the other ground facilities. It would amend the Space Act to grant NASA legal authority to assume liability in excess of available appropriations for privately financed special purpose facilities. I urge the Subcommittee to act expeditiously on these proposals. We are not requesting similar language for the non-facility projects at this time, but may have to do so at a later date.

Third, we are as a matter of policy and practice looking for private sector proposals that represent investments not loans. In short, we are not seeking via these projects simply to borrow money from industry. It is unlikely in any case that the private sector could offer financing at terms better than those obtained by the Government. Although the Administration policy prohibiting straight lease-purchase arrangements contains language permitting exceptions for special purpose facilities, this language is meant to be used as just that--an exception and not a license. Accordingly, we intend to examine closely and to analyze independently each proposal we receive from industry. We will look most favorably at those proposals which, irrespective of their potential for marketplace stimulation, are economically advantageous to the Government. In most cases, this means proposals where the private sector is willing to put its own capital at risk. For example, in preparing the RFP's for the SSPF and the NBL, we intend explicitly to specify that proposers should address the potential for lowering costs to the government by providing over time for multiple use or shared use of these facilities. When proposals are received in response to these and similar RFP's we will conduct economic benefit analyses as part of the evaluation processes. At this point, it is possible that the OIL is a special purpose facility not readily amenable to shared use, and if we decide to seek private financing there, we may need to analyze what other factors should be considered. As I indicated, we do not anticipate this to be the case with the other two facilities.

I do not underestimate the difficulty of measuring in advance a project's potential for fostering viable space markets or actually reducing government outlays in the long term. It is clear that no single approach to the commercial development of space will work in every instance, especially in non-facility cases. With the EDO, for example, it may be appropriate to consider an approach whereby the private investor recoups its initial investment from the Government through a more or less traditional take or pay approach, but depends on user fees from commercial and foreign users for any return on that investment. In other cases, the Government may seek to reduce its hardware costs and foster space commerce by negotiating more favorable contract terms in return for granting the winning contractor exclusive commercial rights to any technology that results from the project. We will need some flexibility to consider innovative approaches proposed by the private sector.

There are also other distinctions implied by the concept of private sector investment instead of private sector financing. We envision the private sector becoming an equity partner, bringing to the table new ideas and management expertise to a much greater degree than currently is the case under normal Government contracting. This addition of intellectual, as well as financial, capital is absolutely essential if we are to achieve the goal of creating national space assets that safely and effectively serve multiple purposes at reduced costs.

Fourth, NASA has made it clear that private investment must not come at the expense of important program requirements and schedules. In this respect, I need especially to emphasize that the facilities I named earlier (ASRM, SSPF, NBL and OIL) are all key in-line operational and development facilities. We have focused most of our early energies on them precisely because of their critical nature. If acceptable and timely proposals for private investment are not forthcoming, alternative funding approaches will be required.

With regard to the non-facility projects: Contacts with Rockwell International about a private investment approach to EDO have been initiated and we are currently in a position to analyze and, if appropriate, act on any near-term proposal without serious schedule risk. Quite frankly, the Space Station Docking Module is not a time critical item at this stage and, as a result, we have chosen to focus our principal attention on the other projects. We are, however, committed to exploring opportunities for expanded private sector investment and involvement in meeting all future Space Station requirements and will examine the potential commercial benefits offered by the docking module in the near future. Let me add that we will need to study carefully the safety and operational aspects of any proposal that includes critical manned flight systems like the docking module. The safety and protection of human life transcends any other objective and will not be compromised.

Special programs and schedule concerns do come into play with the FTS. Given the advanced state of contractor selection, and the delays that would likely ensue if it were to provide the fairest opportunity for the private sector to propose new investment approaches, we are currently reviewing our options with regard to FTS. We expect to make a decision shortly on whether to proceed with our original plan for commercialization.

Let me add that there are other systems associated with Space Station Freedom that we believe may offer greater commercial opportunities than FTS with less schedule risk. Two such opportunities involve elements of the logistics system, where we have already received expressions of private sector interest, and the future solar dynamic power enhancement for the Station. We will keep Congress informed of our activities and analyses in these two promising areas.

In summary, NASA is fully committed to encouraging and supporting expanded private sector investment in space. Private sector investment cannot substitute for Government leadership and program direction. American interests are best served when Government and industry are combining their respective strengths and working cooperatively together. Indeed, our foreign commercial competitors, frequently working in close collaboration with their governments, are making significant investments in space-related research and supporting hardware. If the U.S. is to remain the world's leader in space, we must utilize fully the resources of both the public and private sectors. It is not an "either/or" proposition. Moreover, we need to begin now if we expect to see those investments paying off in the twenty-first century. We are entering a new era of government industry cooperation in space and, like during any time of transition, there will be some false starts and misunderstandings. No one recognizes more clearly than I that this important effort can only succeed with the full support and, where necessary, the authorization of Congress. NASA will endeavor to keep you fully informed of our activities, our progress and, yes, our failures. Thank you. I would be happy to answer any questions.

Mr. **Nelson**. Thank you again, Dr. Fletcher.

Let's go at the second bell in about three minutes here.

Dr. Fletcher, I think everything you have said is very reasonable. And as a matter of fact, the conclusions that the committee was coming to as we have talked to a number of your associate administrators was that you take a major R&D kind of project such as the flight telerobotic servicer, and that was not really a candidate for private financing, as opposed to particularly ground facilities, if one was going to be a candidate for private financing and another was not, I think what you have laid out here today is suggesting the appropriate way which the committee was coming to that conclusion.

And we have elicited a lot of that information from your associate administrators over the course of the last several weeks. So, what you are suggesting here is that there is going to have to be the continuing consultation with the Office of Management and Budget on how we are going to finance the flight telerobotics servicer.

Now, this is going to give this fellow a great deal of heartburn because what I am going to suggest is I am going to suggest to the OMB that rather than penalize your budget on the 13.2, taking the $30 million that you need out of the space station, of which you are building right up very tight on the space station money, that we ought to consider OMB coming back to the Congress and saying we are just going to raise the overall level $30 million, whereas you look at some of the other items, you've got about an $85 million space station processing facility, the spending pool—and I say that with a twinkle in my eye—as another something.

Let's talk about that. Let's adjourn the committee in recess, and we will be right back.

Thank you.

[Recess.]

Mr. **Nelson**. Dr. Fletcher, we were talking before we went to vote about how we distinguish the nuances of the various seven projects to determine which is appropriate for private financing and which is not.

You indicated that you were rethinking the question of the flight telerobotic servicer. So, we would encourage you in that particular case for your successor and for your team that you put together to please come forward if you are going to finally come to the conclusions that that should be within the direct financing of the fiscal year '90 budget.

Then we need a clear recommendation from you and OMB as to how you would recommend to us to proceed. And I would encourage that that not come out of the hide of the space station.

Now, with regard to the others, what we would like is for your comments today to distinguish some different characteristics between the projects. For example, try to give us an idea of how the—what is the technical name of the underwater—neutral buoyancy facility, that on its surface you would say, okay, if a private company built that and leased it to NASA, there may be other private uses that they could make of this facility. And we can understand that, and we would like that detailed to us. It doesn't have to be by you today.

Dr. **Fletcher**. We can provide that for the record.

[The information follows:]

In a written response to the solicitation for interest regarding the Neutral Buoyancy Laboratory (NBL) at the Johnson Space Center, one of the potential proposers stated his interest in the design, construction, financing, operation, and marketing alternative use customers. Comments included the intent to make both U.S. and international space business communities on a non-interference basis to help offset costs. The detailed data submitted by the potential proposer was marked private by the firm concerned. This same firm also made an earlier unsolicited presentation to the NASA Office of Commercial Programs expressing their interest in the NBL project. Their presentation also included statements regarding marketing the use of the NBL to others to help reduce costs and ensure full utilization.

Mr. NELSON. If you would.

Now, with regard, however, to the facility at KSC, this is a space station processing facility. And at first blush, it seems that it is considerably distinguished from a neutral buoyancy facility because there is not going to be any commercial use of this. It is dedicated for the sole purpose of processing the hardware for the space station.

Indeed, in your notice that you sent out to prospective offerors this last January, which was a request for information on the space station processing facility, you indicated there you—NASA indicated—there that it is NASA's intention of having the exclusive use of the space station processing facility, which makes sense. That is what it is for.

So, distinguish for the committee, if you would, why it is appropriate for private financing of that.

Dr. FLETCHER. Mr. Chairman, you quite properly notice the difference between the Neutral Buoyancy facility and the Space Station Processing Facility. In the one case we think we can have sharing at the same time with the neutral buoyancy facility.

In the case of the Space Processing Lab we can't share it. It is dedicated to processing the various components of the space station.

However, that assembly process will be very heavily involved in the early years of the space station while we are trying to put it together and assemble the parts and send them up to orbit for assembly in orbit.

That we can't really share. So, that will be a period of time which will be over, we plan, two or three years. But it might be longer than that.

But after some period of time, that facility will be available for processing other things, much the same as other facilities that are privatized at the Cape. And the expectation is that there will be people sign up—I don't know far along we are in this regard—for use after it has served its primary purpose, and that is, processing components for the initial assembly of the Space Station Freedom.

Now, Mr. Campbell or Mr. McGarvey may wish to add to that.

Mr. CAMPBELL. I think you have set it up very well.

Mr. NELSON. Excuse me one second.

Now, we are talking about way down the road. If I understand, we are talking about the space station starting to be assembled on orbit about 1995 and not completed in its assembly probably until 1997.

Dr. FLETCHER. That is correct.

Mr. NELSON. Operational fully in 1998.

Dr. **Fletcher**. That's correct. So, there is about three or four years.

Mr. **Nelson**. We are looking a long time down the road before this commercial activity would occur.

Dr. **Fletcher**. Long is a relative thing. It would be 1998, as you properly indicated. But this is 1989. This is the 1990 budget. So, in terms of the usual length of usefulness of a building of this sort, it is not a long time.

Mr. **Nelson**. You know, I am just not sure that that is a distinguishment. You are going to have a facility ten years from now, and you ought to make good use of it. The idea is that it would basically be paid back by the time that you got through using it. So, then you would have a free and clear facility along about 1998 that indeed could be used for other payload processing.

Dr. **Fletcher**. Yes, Mr. Chairman. I don't wish to make it black-and-white, though.

It may be that we would have continued use, but not the full facility, even after the space station is fully assembled, because we will be bringing up new things, new experiments and so forth, to the space station, but not nearly to the extent that we have during that very vigorous three or four years when we were assembling the space station.

Mr. **Nelson**. Mr. Campbell, did you have something you wanted to add?

Mr. **Campbell**. To the last point, Mr. Chairman. Our amortization period in the sort of parametric analysis last summer had been about 15 years, although that is subject to the response that we get in the RFP.

And all I meant to emphasize was that when we work on the RFP, the draft RFP that is underway now, there will be a lot more emphasis on extracting other potential uses of this facility than there was in the request for information that you identified correctly.

Mr. **Nelson**. Mr. Sensenbrenner?

Mr. **Sensenbrenner**. Thank you very much, Mr. Chairman.

I would like to follow up on the chairman's questioning on this private financing, if I could. I have a copy of the same document that the chairman referred to in the course of his remarks relative to privatization initiatives.

In one document which is labeled "The Space Station Processing Facility Questionnaire," it says, "Discuss your concerns with NASA's intention of having exclusive use of the SSPF with no limitations by the financer or by the financer contractor."

That to me indicates that the only user is going to be the Government. Can you tell me how this would save money for the Government if there are no other lessees of this facility?

Dr. **Fletcher**. Mr. Sensenbrenner, that probably wasn't worded too well in that questionnaire. But I think when we send out an RFP, it will be much better worded.

The real point is that we don't really, as it was stated in that questionnaire, we don't really see dual use at the same time, but sequentially. We will have intense use of it for a period of three or four years. Then it will have value after that, and that is when we see the private use of that facility. And I think it is different in that respect, quite different from the Neutral Buoyancy Facility.

Mr. Sensenbrenner. As you may know, the Congressional Budget Office put together a staff memorandum last month on analyzing the NASA commercialization initiatives. And this staff memorandum indicated that there would be a net increase cost for the Government with 100 percent U.S. Government lease for both the space station processing facility, the observational instruments lab, and the neutral buoyancy tank.

But there would be a net saving to the Government in the long run with an 80 percent Government lease for each of these three items.

Now, that to me indicates that the breakeven point is somewhere between 100 percent and 80 percent. Now, can you tell me what NASA is doing in making a determination of whether the breakeven point will be reached on any of these facilities? Because I do not think that this committee wants to get involved in something that is going to cost the taxpayers more in the long run, which translates into cost overruns which translates into less support among the Congress and among the public for NASA's activities.

Dr. Fletcher. Mr. Sensenbrenner, I have not read that CBO report, but Mr. Campbell has, and I gather that it really is—the general sense of that memorandum—is pretty accurate.

The 20 percent I don't think should be regarded as a hard-and-fast rule, but it is something on that order. And we have used something like that in our analysis.

So, I don't think that we are too far apart from the CBO document. But I think Mr. Campbell has read it, and I would like him to comment.

Mr. Campbell. Yes, it is. It is good treatment of the status of the solicitations that we are in now. And the 20 percent analysis was done by our centers that are involved in this. And what it represents is sort of a parametric-type analysis, using what we thought were very conservative factors, economic factors, amortization rates and loan rates.

We established that within that range that you just identified, 80 percent range, there would be a net positive benefit to the Government in present value. We feel that is a good test that we should make of these projects, but not the sole criteria that we should use. There may be other benefits that will accrue, and that is why the next step that we are into and the thing that we really need to explore and analyze and then bring forward to you for your consideration and judgment is the actual putting in of the precise values that the contractors that—the respondents—come up with.

That is what is really lacking, as the CBO report indicates. They say the next step is to really put the precise values in that the proposers have and then the analysis takes on a more authentic air.

Mr. Sensenbrenner. We seem to agree that privatization will cost the Government more if there is 100 percent exclusive Government lease. And if there is something less than that, like 80 percent or 85 percent, then the Government ends up saving money.

Mr. Campbell. That is correct.

Mr. Sensenbrenner. I would like to ask why is NASA persisting on going ahead with privatization initiatives when you know you are going to have 100 percent Government lease on many of these items?

Dr. **Fletcher**. I don't think we know that, Mr. Sensenbrenner. I think the jury is out on the two facilities that you mentioned. We have not yet addressed in detail the optical instrument lab at Jet Propulsion Lab, but I think that we will not go ahead and privatize that unless there are factors that indicate that it does save the Government money.

Mr. **Sensenbrenner**. Which private firm is going to be wanting to lease a part of the space station process facility?

Dr. **Fletcher**. I will have to defer on that. I don't believe we have pursued that as vigorously as we have the neutral buoyancy facility.

But Mr. McGarvey is here with me and he can tell you the status of those negotiations.

Mr. **Nelson**. Please identify yourself for the record.

General **McGarvey**. I am Mr. McGarvey, the Assistant Associate Administrator for Facilities Management.

I would like to clarify, if we could, and maybe we could avoid some of the confusion.

The only formal action taken to date has been a solicitation for interest to test the marketplace to see if the people might be interested in investing in these facilities, in making an investment in the privatization activities that can take place in them.

We did not structure detailed RFPs. That is down the road. The real test will come when we issue a formal RFP to those potential proposers and we get back their responses. And we keep it flexible enough that they can propose a series of different financial arrangements and a series of different multiuses of the facilities and we can evaluate those to see if they will still meet our mission requirements and permit joint use or joint operation of the facilities.

In this case, if I could just point out to you in the solicitations, about 30-some-odd questionnaires that you made reference to, Mr. Sensenbrenner, were picked up by prospective proposers in response to that. We got about 14 bona fide or serious responses that would indicate they were interested in receiving an RFP when we get to that stage.

On the neutral buoyancy laboratory, a similar thing. There were about 50 people or companies that picked up the questionnaires, and we only got back about six bona fide serious responses that indicated they would be interested in pursuing it.

Mr. **Sensenbrenner**. It seems to me that somebody—it may not be you, Dr. Fletcher—but somebody is putting the cart before the horse and factoring in the privatization ceiling without at least getting some more hard data on whether there would be anybody who would be interested in leasing a chunk of this facility.

Dr. **Fletcher**. Mr. Sensenbrenner, as I indicated earlier in my testimony, there is more than—more to privatization than simply saving the government money. This is an initiative which we're in the experimental stage on and we think if there is a potential for saving money, we ought to at least try it, providing it isn't exorbitantly expensive. There was one last year that we brought to you that was a little too expensive for most of our blood, but this one is a reasonable thing to try.

And I think the problem we are in, Mr. Sensenbrenner, is that you would like to be convinced that this is a proper thing to go ahead and try to get private interest in before the analysis is done. And on the other hand, we cannot get people to bid on it unless there is some indication from Congress that in fact there is some support for this initiative.

Mr. Sensenbrenner. Dr. Fletcher, what I am concerned about is we either have a fiasco occurring like what happened with Landsat or we end up costing the government money, which is what the CBO indicates for each of the three facilities if there is 100 percent government lease, to the tune of $11 million for the processing facility, $2.2 million for the observational instruments lab and $3.5 million for the neutral buoyancy tank.

Now I don't want to spend my time on this Subcommittee explaining away cost overruns, because that is what is going to kill the space station more than anything that this Congress does or doesn't do. And I am just seeing the matrix developing for some pretty embarrassing cost overruns unless we think about the matrix before we act.

Dr. Fletcher. I think, Mr. Sensenbrenner, you are quite proper in asking the question, but I think comparing some of these initiatives to Landsat is really a little bit unfair: in the first place, I wasn't here when the Landsat decision was made, I think it was a bad decision and we at NASA never would have made a decision of that sort. That was a highly technical enterprise and the idea of being able to recover the money from the private sector was never felt to NASA to be a good idea.

What we are talking about here are ground facilities, and the people that have expressed interest are the major contractors of the country that have built things like this before. This is not a highly technical R&D enterprise. And, for example, that is one of the reasons that we think FTS was reaching too far and we are considering dropping that from the privatization initiative.

But the ground facilities we are talking about are fairly straightforward ground facilities, they normally appear in what we call our C of F line item and there ought to be people interested in that and they ought to be able to tell us how much—if it costs the government, how much it would cost, or if it saves money for the government, how much it saves.

Mr. Campbell. Can I try to clarify the analyses that you're citing, sir?

We did those analyses ourselves and it was an attempt to test without really having the factors of the proposal, the explicit factors of some proposal, what the range of the benefit or the cost as against the least benefit would be.

Now what we did, we had really one solid piece of data in that analysis, and that is the cost of the facility. Those are budget estimates and normally they would come here and be justified and would be a part of our budget. Because of the privatization aspects, we undertook to test the economics of the least purchase approach.

And without any other participation, the cost to the government is indicated based on our analysis of what we think are general parametric economic factors that we applied consistent with the OMB directives on how to prepare these studies.

Then we said what range would the sharing have to be to provide a net benefit, and that is the 20 percent. So you stated it correctly at the outset when you said if someone responds within that range then we have a net benefit to the government.

Mr. **Sensenbrenner**. I would like to change the subject, if I could, relative to the termination liability language that is contained in Section 8 of the draft bill that you sent to Chairman Roe.

Dr. Fletcher, I was heartened by your testimony that you appeared to endorse a case-by-case application of termination liability. However, that is not what the draft language in the bill says.

Dr. **Fletcher**. I am aware of that. But I hope that is clarified, and I tried to do that in my testimony. You can't expect to give—we can't expect you to give us termination liability across the board, but we do need it with respect to these three——

Mr. **Sensenbrenner**. I can understand that being done on a case-by-case basis. It is difficult to draft a general law and I am afraid Congress and this Subcommittee is kind of getting boxed-in in attempting to draft language that would say that it would be applied on a case-by-case basis, which really is not going to give the assurances to the private contractors that you're going to be seeking to bid on on the various things that end up being privatized.

Let me ask a question perhaps and try to solve our drafting problem:

It seems to me that before we apply or give any kind of a promise of termination liability, there has got to be proof of liability of that which is proposed for private financing. How would you suggest we define that in law?

Dr. **Fletcher**. Mr. Sensenbrenner, I've thought a great deal about that, especially in the last two or three weeks, because we understand the problem of the Congress but we also understand the problem of the contractor.

I call it the chicken and egg kind of thing. They are not going to bid unless they get some assurance that, in case we decide to change our minds, that there is some way that they can get their money back. On the other hand, I can see Congress' point of view that unless they see what the real benefits to the government are, why should they sign up in advance?

And the only—the best solution I can think of is to simply give assurances that if you are convinced that it is a net benefit to the government after the contracts are in, that you will provide termination liability, providing that—and then you will have to put the stipulations in, but I would guess it would be something like we come to you after the proposals are in and give you a sense of what the winning contractor proposed and why it does make sense or doesn't make sense to the government to go ahead with that contract, that termination liability, but we can't give you the proprietary data from each contractor but we can give you the data from the winning contractor. At least that's my way of dealing with it.

Mr. **Sensenbrenner**. Wouldn't, from a practical standpoint, it be better if Congress should decide to either de-authorize or de-fund one of these projects, simply to put the termination liability in the package that is laid before Congress at the time that decision is made?

Because that way the total cost of the de-authorization or the defunding includes the termination liability and that way Congress knows that it has to pay some money up front in order to get NASA and the government out of the contract which it has signed, rather than simply saying we are zeroing out this particular proposal for this and subsequent fiscal years.

Dr. **Fletcher**. Mr. Sensenbrenner, I think that is something that needs to be worked out, the exact language I have to——

Mr. **Sensenbrenner**. I agree with what you are saying, if Congress should change its mind and not decide to go ahead with the project, that decision ain't free and it is going to cost the government some money for a change in policy.

My feeling is that this particular piece of the authorization language ought to be deleted and we ought to have some subsequent hearings on this and come up with some kind of a termination liability bill which would be acted on subsequently.

Dr. **Fletcher**. That is entirely conceivable.

Mr. Frankle, do you want to comment?

Mr. **Frankle**. Yes, Mr. Sensenbrenner, I think we can certainly work that way. The discussions you were talking about with Congress certainly can be worked that way depending on when those things occur.

As we have been trying to say so far this morning, there is a chicken and egg and unless—we are not going to get the appropriate proposals, we are not going to get the contractors to propose in a way and then come up with creative ways unless they have some reasonable basis for believing that they might be allowed to proceed.

If that approval or authorization or whatever comes early in the process, prior to the request for proposals, that may well be workable. If it doesn't come until after the proposals are in—we can analyze it but I fear very strongly we will not get the right proposals because no one will believe that after they win a competition, after the proposal is evaluated, then they are going to look to see if they can get a whole new piece of legislation passed. It has to be early in the process if it is to have any chance of success at all.

Mr. **Sensenbrenner**. I don't quarrel with that, but I'm looking down the road to see what happens if one of these projects should be terminated for one reason or another. And with Gramm-Rudman applying, that means every dollar that we pay in termination liability is a dollar out of something else probably in the NASA budget and the NASA budget could really be goofed up and a lot of good projects that everybody agrees on ending up getting cut simply because of a poorly drafted termination liability provision and the axe could fall on the neck of somebody that nobody wants it to fall on.

Dr. **Fletcher**. I think you have expressed it well, but we need to distinguish between those things that are absolutely necessary to continue our program, like the Space Station Processing Facility and like the Neutral Buoyancy Facility. One way or another they have to go ahead if the space station is going to go ahead, so that we've got to figure out some way of doing that. And I think your suggestion is on the right track. I think we will have to work on the details of that.

Mr. **Sensenbrenner**. Thank you very much.

Mr. **Nelson**. You might be thinking about, short of legislation, what other kinds of signals could be given with regard to termination liability other than it being in the legislation.

Dr. **Fletcher**. Yes, we are thinking of that. Off the top of my head, my feeling is that some sort of a letter from the appropriate committees, presumably the authorization committees indicating that if appropriate criteria are satisfied we intend to provide the termination liability, something of that sort, would I think be enough to get a suitable number of contractors to get on this.

Mr. **Nelson**. Also consider this: that as we look at facilities such as the Space Station Processing Facility, to what degree do we have a responsibility to the true commercial ventures that are already there or that have been planning on setting up payload processing facilities and have done it entirely with private funds, with no government up front funding?

Dr. **Fletcher**. Mr. Chairman, you've put your finger on a very important question. I have a little problem answering it because of a perceived conflict of interest. I was part of the company that provided the first facility. I don't have a legal recusement requirement but I do have an awkward position there, since Astrotech was the one that built the one facility anyway. I am afraid I need to defer to one of my colleagues or at least provide it for the record.

[The information follows:]

The Astrotech facility is capable of processing small payloads and commercial satellites but is not large enough to accommodate the processing and checkout of the large structure elements and modules of the Space Station.

Mr. **Nelson**. The news reports have been replete with other aerospace firms that have been looking with some interest about establishing processing facilities that could be joint use between the government and the private sector, and I don't think any of them have been zeroed in at the enormous scope and specificity of this kind which this would be for space station processing.

But come 1998 what you have testified to today is that this thing would then be open to the commercial market and it would be a facility that in essence would be completely paid for with government funds and then would be available—you're shaking your head no. Tell us about that, Mr. Campbell.

Dr. **Fletcher**. Partially paid for.

Mr. **Nelson**. Go ahead.

Mr. **Campbell**. I wasn't shaking my head. [Laughter.]

Mr. **Nelson**. You, by extension, behind you were shaking your head.

Mr. McGarvey.

General **McGarvey**. In a sense of the amortization and if we are successful in a partial equity going in, you will have a positive benefit to the government and the government will not have financed all of it. The proposal will have financed perhaps 20 percent, perhaps 25 percent. And downstream what we would hope in the draft RFP's, the response we would get back on the draft from the proposers is to get a feel for how they would propose joint use of it. And, as you alluded to before, the first five years or so it has to be dedicated almost solely to NASA. But after that five years, for the next ten years you certainly may be well able to share 50 percent of the facility with our responsibility simply being in the replenishment of the logistic modules and logistics re-supply.

So we believe there is a strong possibility for joint participation in the efforts and joint use of the facility in reducing the cost to the government. But we won't know that until we have tested the marketplace with some specific RFP's that gives them an opportunity to do that. All they have done to date is indicate an interest in financing of it.

So we are looking at the moment, Mr. Nelson, we have the procurement and development teams working at all three centers to come up with an acquisition strategy and flexibility that can perhaps achieve these goals. We will have them in, we are going to conduct workshops with them and then we are going to put together a draft RFP hopefully next month in the month of April.

We would ask for the comments on the draft RFP from the potential proposers and then we would come back and formalize a formal RFP and present that then in the marketplace and we would test the water and see if the capability is there. Until we do that I think we have just got a lot of speculation.

Mr. NAGLE. If the gentleman would yield: But the problem with that is that we put up the $30 million to find out.

General MCGARVEY. You haven't put up anything to find out.

Mr. NAGLE. I'm sorry, I thought you were asking $30 million for termination liability; you're not?

Dr. FLETCHER. I think, Mr. Nagle, we are asking for termination liability if, indeed, the proposals were of proper value to the government. We always have the option of not going ahead. We are not talking about compensating contractors for their bid and proposal expenses, we are only talking about compensating them for the work that they have done in case we changed our minds.

Mr. NAGLE. Up to $30 million.

Dr. FLETCHER. Up to $30 million, but that does not include the bid and proposal costs, so we do not have to—if the thing does not turn out to be viable—the winning contractor is not a viable thing for the government to do, there is no termination liability at that point because they haven't been awarded any contract.

Mr. NAGLE. I thank the gentleman for yielding.

Mr. NELSON. Before I turn to Mr. Schiff and then Mr. Nagle, I want to suggest to you you might be thinking about—since you are reversing your proposal on the Telerobotic Servicer, and if you should determine that you want to reverse your proposal in any of the other development projects, what other items in the budget would you want to apply the financing to?

Because just in development projects in 1990 we have a total of $208 million, and you've got a total budget of $13.2 billion. And we can't go out and likely get another $208 million over and above what you have requested given this budgetary climate, so you might start looking at some switches that can occur in the financing.

Dr. FLETCHER. Mr. Chairman, you are absolutely right. In fact, we have looked at a fairly large number of programs, discarded most, but we have two or three that at the appropriate time we will bring forward. But we figure we've got our plate pretty full as it is with the seven projects that we started with; we have already begun to back down from a couple of them. And I think we had better let them sit, at least for the near term.

Mr. **Nelson**. That's the problem. We have got to go with the Telerobotic Servicer, and the fact that you are backing down from it doesn't make it any easier because we don't have a money tree that we can simply supply—how much is that?—$30 million in Fiscal Year 1990 and $173 million in the four-year period.

Dr. **Fletcher**. You're absolutely right, Mr. Chairman. I think that's why OMB has gotten a little heartburn on this, on this particular program. I don't think that the idea of backing away from it, as I understand it, is abhorrent to OMB, it's just where is the money going to come from?

Mr. **Nelson**. Isn't it interesting that the discussion this morning is not a discussion of us being a jurisdiction of the space program, what the discussion is is budgetary financing and creativity in budgetary financing. And that is what has consumed the discussion of the entire Committee this morning. I think it is purely a commentary on the times. It is a commentary on the budget deficit.

Dr. **Fletcher**. Mr. Chairman, I think you put your finger right on it. But I spend most of my time in the private sector: creative financing is a good thing if it works. And sometimes it doesn't work. And that's when you are in trouble. You don't want to try it on huge projects, you want to try it on something that you think will work. And that's what we have tried to do.

Mr. **Nelson**. Mr. Schiff, I want to turn to you. And let me just say whenever you say—I remember that drill that we went through last year on the CDSF and all of the competing things that were going on there and the politics that got into that and the jurisdictional egos that got into that, and the intra-Administration fights that got into it. And that was simply a nightmare that we went through.

Mr. Schiff?

Mr. **Schiff**. Thank you, Mr. Chairman.

Dr. Fletcher, I'm going to ask your indulgence because again I am the new member of the Committee, I want to cover two areas that have been covered in the last couple of years to bring myself up to speed: the change in the patent laws that NASA advocates, could you briefly summarize what changes NASA thinks should be enacted in the patent laws?

Dr. **Fletcher**. Yes. It is in my testimony but I think Mr. Frankle was the one that drafted that language and I would like him to respond to it, if it's all right with you, Mr. Schiff?

Mr. **Schiff**. Certainly.

Mr. **Frankle**. The language that is there accomplishes two purposes: one of them is it provides some certainty to corporations and individuals thinking of getting involved in space activity. It provides them with some certainty about the applicability of U.S. patent laws to activities in space.

We think that there is a fair chance that patent law would develop that way on its own, given time. But because of the large amounts of money that are involved in the activities in space and the potential for some very large awards, we think it is only fair to provide certainty to those companies that are contemplating this that yes, they now know what law is going to apply to it and that they will be able to protect any intellectual property that is developed in space.

There also is a second section which actually appears as an exception to the statute, which says that U.S. patent laws will apply in those cases except as provided by international agreement. That section is required in order for us to implement the agreement, the international agreement, intergovernmental agreement with the space station in Article 21, I believe, of the IGA. We have agreed—all partner states have agreed not to apply any other laws concerning patent secrecy to prevent the filing in another jurisdiction.

We had one section law, 35 USC 184, which would act to do that in the event of activities involved on U.S. registered elements of the space station.

So we need to have the ability by international agreement to waive that statute and that is provided in this section. The remainder of it is just, I think, codifying what everybody believes should be the appropriate law on patents in space.

Mr. SCHIFF. Mr. Frankle, wouldn't a section of U.S. patent code that says U.S. patent law applies in space have to be ratified by international agreement anyway? In other words, how can we say our patent law applies under our law if it is not necessarily recognized under some other country's patent laws? Wouldn't we have to have international agreement on that?

Mr. FRANKLE. No, sir. This just says that basically the U.S. patent law will apply to vehicles in space that are under the jurisdiction or control of the United States, since there our vehicles basically we can make our patent law apply to it. And it just puts beyond any doubt whose law applies.

Perhaps there are circumstances where you have a commercial piece of infrastructure, something like the space—like the CDSF or an external tank which is being used as proposed maybe by Global Outpost and you have a foreign user who has attached something to it. There could be a great deal of confusion as to which law—this just says since it is under U.S.—if it is registered under the Registration Convention Outer Space Treaty it is clear that U.S. law would apply, but not everything gets registered, not everything gets registered right away. So if it is not, there is a need to provide some certainty as to what is happening. And that is what it is for. This has been around for several years, this provision, and I believe it is reasonably non-controversial. There has been strong support for it.

Mr. SCHIFF. It is not passed yet?

Mr. FRANKLE. It has passed twice in the House but not in the Senate.

Mr. SCHIFF. Something is going wrong somewhere.

Mr. FRANKLE. There was a question as to whether that was really needed. But now, especially with the signing of the IGA, it is definitely needed, and it has been introduced in both the House and the Senate this time and we are working actively with the various committees to get its passage this time.

Mr. SCHIFF. As one of the few lawyers in Congress, I can tell you I have told state legislative bodies that oftentimes it is better to be safe than sorry in terms of guaranteeing a particular legal posture.

The second and final area I would like to ask you about is the exemptions that NASA apparently wants to the Freedom of Information Act. Perhaps I should address this again to Mr. Frankle: could you explain briefly what those exemptions are?

Mr. **Frankle**. Certainly. What it is basically is we don't really see it as a major exemption from the Freedom of Information Act, what we do see is we think there is an inconsistency as it exists now, especially with respect to NASA, with respect to certain technical information that we are developing. We have several programs and we are starting some new ones which are aimed specifically at developing new technologies, which is there to insure U.S. competitiveness to help domestic industry maintain its place in the world markets. That data, once developed, could not be exported without a license.

Mr. **Schiff**. Right now.

Mr. **Frankle**. Right now. If a contractor had a piece of that data and wanted to send it overseas, they would have to go either to the Department of State or the Department of Commerce and get a license to export it. However, while it is still in the possession of the government, while we still have it, because of just the way the Freedom of Information Act is written—since we would have the option as part of our program of exporting if we deemed it necessary, we are not allowed to withhold it. Under the Freedom of Information Act, we cannot ask the requester—under the Freedom of Information Act, the requester who he is or where he is from; there is no distinction between domestic and foreign.

Mr. **Schiff**. A foreign national legally here could make a request for this information under the Freedom of Information Act.

Mr. **Frankle**. That is true. We get requests frequently simply from foreign capitals. They don't even have to be living here, they can just ask for Agency records. These are included. And since we would, under part of our program, have the ability to—if we thought it was in the best interest of the government, we would have no ability to withhold it under the Freedom of Information Act. We're trying to make it so that we are not frustrating the export control laws which already exist through the use of the FOIA. We are not asking for any ability to expand our rights to withhold information from domestic or anything, it is just that we can withhold that information if it could have been withheld under the—if it couldn't have been shipped out without a license, and if people wanted it, they would have to go through the licensing process to try to get it.

Mr. **Schiff**. Under the theory that releasing the information through the Freedom of Information Act essentially exports it without going through—we're seeing that as a loophole on the export license.

Mr. **Frankle**. We believe it is an unintended loophole. It was recognized in about '83 and there was an attempt to amend the FOIA generally that, for various reasons, didn't succeed. At the time it was recognized that the biggest problem in this area of unclassified high technology was with the Department of Defense and with NASA. In 1984, the Department of Defense—in their authorization bill, the Department of Defense was given the authority, very similarly worded to what we are asking here. At the time that the general amendment to the FOIA was withdrawn, it was withdrawn because the major part of the problem had been fixed. It was explicitly recognized that NASA still had a problem and that had to be worked in the future. That's what we're trying to do here.

Mr. SCHIFF. Dr. Fletcher, let me say that I notice from the notes I receive from the Staff, one of the reluctances on this Committee to endorse that particular proposed legislation is the feeling that perhaps—just perhaps—jurisdiction of that matter belongs to the Government Operations Committee which supervises the Freedom of Information Act.

I want to advise you and invite you that I happen to serve on the Information Subcommittee of the Government Ops Committee and—although I'm not endorsing the wording, I have not reviewed it—if I could be of service to your staff I would invite you to come to see me.

Dr. FLETCHER. That's the best news I've heard all day, Mr. Schiff.

Mr. SCHIFF. Mr. Chairman, that's all the questions I have. Thank you.

Mr. NELSON. Since you are one of the few lawyers in Congress. [Laughter.]

You can lend your expertise. This is an area of legitimate concern. What we're going to plan to do is have the hearing on this later on and try to build a solid record, so that we can have a better idea of which way to go, recognizing that a lot of the jurisdiction on this will be within the Government Operations Committee.

Mr. Nagle.

Mr. NAGLE. I want to first thank you, not just for today but for your work in the Agency. I am one of your more hostile questioners; I don't mean hostile personally but I acknowledge your contributions and I want you to know that I appreciate the service and the effort you have made.

Dr. FLETCHER. Not hostile, just thorough. [Laughter.]

Mr. NAGLE. I am afraid you will think so when we're done today. [Laughter.]

Quoting from your testimony on page four:

> The overarching objective of these commercial initiatives embodied in the U.S. National Space Policy which states that the expanding private sector investment in space by the market-driven commercial sector generates economic benefits for the nation and supports government space sectors with an increasing range of space goals and services. Recently President Bush confirmed his support for these objectives.

And now clearly one of the branches of that attempt to commercialize space apparently is going to be at, at least the exploration stage, the ASRM. That puzzles me because I read a report prepared by NASA: Space Shuttle Advance Solid Rocket Motor Acquisition Plan, dated March 31st, 1988, and it says:

> The key factors of the Phase B studies analyzed in selecting the segmented motor include the following:

These are the factors you were looking for when we started considering the ASRM:

> Flight safety design margins and reliability; industrial safety; performance; productivity; inspectability; transportation and handling; development verification

risks; manufacturing facilities; test facilities; launch facilities; operations and system interfaces.

I did not see the key factors when we started on the ASRM as being another example of the potential for the commercialization of space; indeed, it was not even mentioned by NASA just a year ago. What changed?

Dr. FLETCHER. Well I will have to rely on my memory, but if it is wrong I will ask the team here to support me. But it did not occur to us when we first decided to go ahead with the Advanced Solid Rocket Motor that a part of it, only a part of it, which is the facility part of it, might lend itself to privatization. And we were reminded of that by the OMB who have signed up to the President's commercialization policy, and we had to take a look at it and see what could be done.

And in fact they were right at the time that it is conceivable that somebody who wanted to pay for the facility itself—we're only talking about the facility, not the whole program, I've forgotten what fraction of the total it is, let's say $3- or $400 million, it did occur to us that sure if somebody had a good idea, one of which might be a different site than we had picked that was advantageous to the government, he could in fact produce a facility with lower cost to the government.

And we were convinced at that time that since there were alternate sites proposed, particularly as I recall one in Alabama, that we ought to give them the option of bidding as what we call a co-facility. That seems less likely at this time.

But nevertheless we went ahead with the RFP's on that basis and they may come up with some ideas, which we are not sure of at this point, that does in fact save money for the government by privatizing. I don't know what they might be. I think it is not too likely. But I am not involved in the evaluation process so I can't really answer that question, but it did seem at the time that there was an opportunity for privatization and an opportunity for the government to save money thereby.

Mr. NAGLE. The change was you didn't explore this possibility when you did this March 31st, 1988 schedule?

Dr. FLETCHER. No, at that time my memory serves me we had not considered privatization. We were reminded that it should be considered by the OMB.

Mr. NAGLE. Let me read from this report on page nine:

> Phase B contractor data generally favored a new government-owned, contractor-operated go co-facility to be designed, constructed and operated by a contractor on government property. Findings were based on the apparent lower total government cost, return on investment, taxes, insurance, et cetera, reduced termination liability, acquisition of permits, equalization of competition, flexibility for NASA in terms of utilization, modernization, growth of recompensation contract efforts.

It appears that somebody, when they did this study, considered that because they recommended the go co-plan.

Dr. FLETCHER. There's no question at the time we wrote that document—in fact, nearly every one of those still apply. And it may very well turn out to be that all of them apply but we cannot be sure of that until we have received the proposals from the contractors.

Mr. NAGLE. You say that OMB called to your attention this option.

Dr. FLETCHER. That the facility could be privatized, yes.

Mr. NAGLE. OMB wrote you a letter on October 19, 1988 and here's what they said about lease purchase agreements:

> Lease purchase arrangements are more costly to the Federal Government than the outright purchase or construction of an asset, since the Agency must pay the cost of the lessors' borrowing, which is more expensive than the cost of Treasury's borrowing. These purchase arrangements also create secondary markets for Federal Government borrowing which competes with Treasury borrowing and drives up the cost. In addition, they encourage pork barrel spending and bias the decisionmaking. Furthermore, unlike assets that are purchased directly, property acquired in the lease purchase is encumbered with respect to the disposal by the Federal Government.

That letter was written to you on October 19th, 1988 by Joseph R. Wright, Acting Director, the subject was the lease-purchase arrangements.

When did OMB suggest that this memorandum was no longer operative?

Mr. CAMPBELL. There is an exception, Mr. Nagle, in the special purpose facilities and we consulted with the OMB at the time we received the letter, and they indicated that—I think there is another sentence that addresses these special purpose facilities will be reviewed and determined on a case-by-case basis during the budget process.

Mr. NAGLE.

> Such arrangements understate the true cost of the capital acquisitions and a lot of the importance of lower near-term outlays in budget authority at the expense of longer-term costs.

Mr. CAMPBELL. This has to be determined in the selection process.

Dr. FLETCHER. Mr. Nagle, let me just add that was a broad memorandum that applies to lease purchases generally and I think that we have tried to respect that. They were quite—OMB was quite well aware of that document when they encouraged us to go ahead with the possibility of privatizing the ASRM facility. So I am sure that they considered that that might be an exception to that blanket document.

Mr. NAGLE. I know you are a messenger for the Administration, but aren't we really in a situation with at least commercialization of ASRM, aren't we trying to make a theory—aren't we trying to prove a theory on what NASA originally showed would not be a profitable undertaking?

Dr. FLETCHER. I think that is going too far, but I think—because at the time that we sent out our RFP there were several alternate locations considered besides the one at Yellow Creek. And it is quite conceivable that the alternate locations might show the considerable cost improvement to the government.

At this point though you are closer to being right than I was at the time because basically the contractors that have proposed those alternate facilities, alternate locations, now say that they no longer think that they can make a proposal of that sort. But nevertheless the RFP still stands, we cannot go back and rework the whole thing and they may come up with some ideas that we haven't thought of that shows the net cost to the government.

Nevertheless, having said that, you are probably close to the truth. I don't want to pre-judge that competition at this point. Even though I won't be involved, it is not fair to the selection official to make that conclusion prematurely.

Mr. **NAGLE**. The CBO office said—and I wonder if you concur or disagree, because of the things that we're talked about this morning is the 20 percent offset with commercialization. You said it would make the thing flow better, but they said:

> There is not likely to be any demand for resources outside the U.S. Government for three of the seven proposed projects: the Space Station Flight Telerobotics System, Advance Solid Rocket Motor plant and the Observation Instruments Laboratory.

Do you agree with that?

Dr. **FLETCHER**. I do not disagree with that statement.

Mr. **NAGLE**. So we cannot expect, if we go to commercial policy on ASRM, that we will in fact see lower costs by commercial participation.

Dr. **FLETCHER**. I think the important words there are "was not likely." I don't think that you can set aside that possibility, however.

Mr. **NAGLE**. I guess what is troubling me is, in trying to look at the out-years on this thing, I know that lease-purchase agreements have—they get you over the immediate hump, but the problem is when we start incurring the cost of the lease-purchase agreements in the mid-years and out-years, we are going to be incurring that at the same time that hopefully this country will be building the shell-sea, we will be undertaking construction of the space station facility itself.

So are we not, if we go down this road, although we look good this year, creating at least the potential for a tremendous crack as we get into '92, '93 and '94, because our expansion of our budget obligations for the lease-purchase agreements that were so cheap to start with are now starting to accelerate rather rapidly?

Dr. **FLETCHER**. If the intent were simply to pass along costs this year to some outyears, that would be the case. I think the jury is still out on whether that is in fact the case.

I think your observation on the ASRM is probably accurate, but we really can't change our philosophy in the middle of the competition, and we ought to stick by it and see what the proposers come up with.

If in fact they don't make the net saving to the government then we won't go ahead with a GOCO—I would like to remind you of one thing though and that is the 20 percent rule—and forgive me if I am wrong and Tommy Campbell will speak up—I think that does not apply to the ASRM, that applies to the other three facilities.

Mr. **CAMPBELL**. That is right. It applies to the other three facilities.

Mr. **NAGLE**. We agreed that the probability of commercial interest in five of the seven projects that are supposed to serve as the marking stone of the Administration's commercialization have very little likelihood of commercial participation.

Dr. FLETCHER. Mr. Nagle, at the risk of changing the sense of your statement, I would say it is likely that three out of the seven will provide appropriate commercialization, but the jury is still out on that.

Mr. NAGLE. Would you identify those three?

Dr. FLETCHER. Neutral Buoyancy Facility, the Space Processing Facility, and the EDO. The Optical Instrument Lab is also a possibility, but that is downstream a little bit, and we are not asking for termination liability on that yet.

Mr. NAGLE. Would you furnish to the committee—I know you don't have it today—the specific exemption with regard to the ASRM initiative that you received from OMB?

Dr. FLETCHER. We can do that for the record.

[The information follows:]

The agency proceeded with the commercialization of the ASRM based on the attached letter from OMB.

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

MAR 28 1988

Honorable James C. Fletcher
Administrator
National Aeronautics and Space Administration
Washington, D.C. 20546

Dear Jim:

I appreciate your strong support for the President's space commercialization initiatives. As you recall, these initiatives were still under consideration at the time the President's budget was completed. During the budget deliberations, we determined that the Advanced Solid Rocket Motor (ASRM), including a new production facility, was an important budgetary priority. Since the National Space Policy and the commercialization initiatives have been approved by the President, it now seems appropriate to thoroughly examine and vigorously pursue privatization opportunities for the ASRM production facility.

The President's new Space Policy calls for completion of agency implementation plans by May 5, 1988. As part of your overall commercialization activities in support of the policy, NASA should thoroughly examine, vigorously pursue and exhaust commercial options for the ASRM production facility.

The fact that NASA is considering commercial options for the ASRM facility, in support of the President's space policy, should be included in the ASRM testimony to Chairman Nelson at the end of this month. In addition, the ASRM report due to Congress in April, should specifically include an option for privatization of the ASRM production facility.

I am requesting that privatization options for the ASRM facility, be developed by your task force for implementation of the Space Policy and commercialization initiatives. NASA must thoroughly examine, vigorously pursue and exhaust commercial opportunities for the ASRM facility before making any commitment. To underscore our commitment to the commercialization objectives in the President's Space Policy, I plan to withhold apportionment of ASRM facility funds until this is done satisfactorily.

Please let me know if I may be of assistance in your efforts.

Sincerely,

Robert K. Dawson
Associate Director for Natural
Resources, Energy and Science

Mr. **Nagle**. When was that received?

Dr. **Fletcher**. I would have to rely on my memory, but it was in about the summer or so of last year.

Mr. **Nagle**. Before this was written?

[Demonstrating.]

Dr. **Fletcher**. Before which?

Mr. **Nagle**. Before the OMB letter to you.

Dr. **Fletcher**. Before the lease purchase letter, yes, I think so.

Mr. **Nagle**. I want to go into a little different area. I want to ask you, first of all, are you about to receive a report from any agency, any group, any commission, any independent composition of people—I want to be as generically broad as possible—from any source whatsoever that indicates that the ASRM is not at this point the path to pursue in light of what they feel are serious safety defects with the orbiter itself?

Dr. **Fletcher**. Mr. Nagle, the last time I was before this committee you asked the same question, and I answered to the best of my knowledge, no.

That is no longer true. I am aware of a report that is likely to be issued soon, which is a report of the ASAP, Aerospace Safety Advisory Panel. That seems to take the position that that money could be better spent on improving the reliability of the existing solid rocket motor.

Having said that, though, I think if they have their druthers they probably would recommend that we do both. But I think they are concerned, as you are, about the total availability of funds, and so they felt, as I understand it—I haven't talked to them yet, but I just saw the report, I guess yesterday for the first time.

Mr. **Nagle**. Do they say in their report that there were "serious safety defects"? Did they use that term?

Dr. **Fletcher**. I don't think so——

Mr. **Campbell**. To the orbiter structure.

Dr. **Fletcher**. The orbiter structure is a different problem. I thought we were talking about the ASRM.

Mr. **Nagle**. I think they said, if I am correct, that in light of the serious safety defects to specific parts of the orbiter that they did not recommend pursuing the ASRM at this time because they have to fix the serious safety defects.

Dr. **Fletcher**. That is not my recollection of the wording, although it was a fat report and I could be mistaken.

My impression—and by the way, I think you are going to have a hearing on that, Mr. Chairman—my impression——

Mr. **Nelson**. We are. We invited them to testify last Tuesday, two days ago, and they declined to testify.

Dr. **Fletcher**. The report, unfortunately, was late. It was late getting to me. What is today? Thursday. I saw it Tuesday for the first time. I read it carefully because I had heard that there was some concern about safety.

We are always concerned about safety, but the impression I got from the report, there were two separate issues. One is the concern about improving the reliability of the orbiter, and we have the same concern, and a lot of the things that they suggested on improving the orbiter we were going to take a serious look at.

The other question was, was the advanced solid rocket motor worth spending the money, and I cannot remember the exact wording—and it was a draft document, so it may change—but I think it said that the advanced solid rocket motor, while it may be a good thing to do, that money could more properly be spent on improving the reliability of the current solid rocket motor.

Now, if my impressions are incorrect, we can supply—you will be supplied with a complete report when it is issued, and I cannot remember the date on that, but it is soon.

Mr. NAGLE. The safety defects that they identified on the orbiter were with regard to the wing, the tail?

Dr. FLETCHER. They did not identify those as safety defects. Those are things that they identified as worthy of examining in order to improve——

Mr. NAGLE. Repair?

Dr. FLETCHER [continuing]. Hold it in order to improve our ability to launch on time. That was their concern. We have had trouble with upper atmosphere winds. As you know, we had a delay even in the three latest launches. We had to delay one of them a day. The others have been delayed by a matter of hours, and they are trying to get around those delays—none of them are launched unsafely—trying to get around those delays by beefing up the structures so that we didn't have to worry as much about the upper atmosphere winds.

I don't believe if you read that carefully that they indicated that there was an unsafe situation on the orbiter.

Mr. NAGLE. Would you recommend to this committee that we wait—in terms of the ASRM request this morning that we wait until we see that report and have seen the recommendations?

Dr. FLETCHER. I have no objection if you wait until you have seen that report.

Mr. NAGLE. Do you think it would be prudent for us to do so?

Dr. FLETCHER. I think I am neutral on that one, Mr. Nagle. I don't think the report was all that negative about the ASRM. It was very positive on a large number of improvements to both the solid rocket motor and the orbiter itself.

The large number is our own list, of which they are wanting made public, and I think that we will take a look at all of those things and at the appropriate time, if they can be done, we will try to implement them.

Mr. NAGLE. I was told yesterday that the reason the Atlantis launch is going to be delayed is because the Atlantis itself has been cannibalized so much for replacement parts for the other orbiters because we don't have a spare part inventory sufficient to keep all of our orbiters in service.

Is that the reason for the delay of the launch of the Atlantis?

Dr. FLETCHER. Absolutely not.

Mr. NAGLE. Has the Atlantis been used for spare parts for the other orbiters?

Dr. FLETCHER. That is a question which I cannot answer, and I am afraid we do not have anybody from the STS Program Office. We will have to supply that for the record, but I can give you my impression.

My impression is that there was very little cannibalization of the Atlantis for any of the earlier flights. We have a much, much better spare parts inventory now and a much quicker way of accessing them.

The only time that we have to juggle—I don't call them parts—but juggle things from one orbiter to another is when we have engine problems. There is a limited number of qualified engines. We had a problem on the Discovery on the second launch, in that we were concerned—there was no defect that we could see, but we were concerned that the process by which they were constructed may have been done wrong and could have led to stress corrosion, and so we did have to juggle engines back and forth between orbiters.

I can't remember whether any of them were deliberately taken from the Atlantis or not, but I don't think that had anything to do with the delay of the Atlantis.

Mr. NAGLE. Or any of the orbiters. I may have the wrong name.

Dr. FLETCHER. We will provide that for the record because the folks here—the Space Transportation System, those folks are not here today.

[The information follows:]

The NSTS program has established policy and procedures which severely restrict the practice of cannibalizing spare parts from one orbiter in support of processing another orbiter. In addition, KSC Orbiter Logistics has taken the opportunity during the last two and one-half years of downtime to build up the inventory of spare parts in order to keep all of the orbiters in service.

The results of these efforts have been successful. For the ten flights prior to, and including 51-L, the average change-out of spare parts was just over 100 line replaceable units (LRUs) per flight. Over 20 percent of these change-outs required cannibalizations. For the three flights since 51-L, we changed-out nearly 2600 LRUs with only 18 cannibalization (0.7 percent). None of these cannibalizations had adverse impact on launch dates for any orbiter, including Atlantis.

Mr. NAGLE. Here is my concern, here is my concern. I think the agency has been in a budget squeeze for a heck of a long time. I think the budget squeeze sometimes has driven the policy, and I think that is dangerous. I think the push to get the ASRM may be obscuring our vision, what we need to do today for use tomorrow, not five years out, and I am getting different information about the situation on the orbiters than you are.

But we will wait and see the report and see where that takes us.

But in light of the fact that we don't have an identified mission yet for the ASRM in terms of its increased lift capacity, should we not bring ourselves to 100 percent today before we start on that new motor?

Dr. FLETCHER. Mr. Nagle, I think that is—both observations are right on track. There is a danger because we are starting on a brand new motor, advanced solid rocket motor, that we might tend to ignore a current problem, and there are always current problems. This is never going to be a completely safe vehicle. We have got to make sure that doesn't happen. So that observation is correct. There is that danger.

And the second part, whether we ought to reconsider the ASRM, is also an astute comment. However, I want to remind you that it was this committee that asked us to look at a competitive contractor for the solid rocket motor, and this was back in 1986, about the time that I came on board, and it was that idea that came from this committee that led us to look at a competitive contract.

We thought if we are going to spend that much to bring up another contractor to build a solid rocket motor we might as well make the new contractor build a better solid rocket motor, and in fact we not only expect it to be a better solid rocket motor but we expect it to have additional capacity.

That was not the original intent. The original intent was to be able to change contractors when we thought we had a problem and to keep the pressure on the principal contractor, and that still is one of the intents, intended purposes of the ASRM.

Mr. NAGLE. I am concerned that budgetary considerations and economic theory is driving the space policy at NASA. I think we are so desperate to find some commercial venture successful that we would explore every option and pursue areas when in fact we should be taking of the house we have built right now.

Dr. FLETCHER. I think that observation is absolutely correct, but there is nothing new about that. I think even during the Apollo days budget considerations drove policy considerations. We almost didn't get to the moon because they started cutting back on our budget two years before we got there. It was a close shave.

So that first observation is correct. Whether it can be applied to these commercialization initiatives I think is the question. I think we have got to look at the private sector and see what they can do to help.

We have had one spectacular success, as is well-known, and that is the communication satellite. NASA could have chosen to go ahead and launch communication satellites for the benefit of the industry as a whole. We chose not to. We turned it over to the private sector, and that is an outstanding success.

We are still on that track, and these are small initiatives coupled with many, many other initiatives having to do with secondary payloads and things of that sort. Spacehab we mentioned over the years to try to get the private sector more heavily involved.

I don't think the problem of budgeting is driving that policy.

Mr. NAGLE. You would concede that the reliability factor—I don't know quite what that means, but we will take it at face value—the reliability factor has forced the window of launch availability dates dramatically narrower after Challenger, after the Challenger accident, in light of studies done on the orbiter?

Dr. FLETCHER. I think that is right. It has caused us a lot of grief. The weather particularly has caused—we have put a lot more restrictions on the weather, and the observation is correct. It does give us a problem when there is a small window of opportunity.

By the way, it is really scary on the first day of the Magellan launch. I was just told this week that it is 18 minutes on that first day. It increases to somewhat longer on the later days. So those of you who are planning to go down for that 28th launch, you might be advised that it might not go on that day.

So you are quite right in expressing the narrow window of opportunity.

Mr. NAGLE. If we made the replacements on the vehicle that have been recommended, we would have a bigger window?

Dr. FLETCHER. That is correct.

Mr. NAGLE. Tell me what reliability means. What are the reliability factors? What does that mean?

Dr. FLETCHER. There are two kinds of reliability. One is the reliability of the vehicle once launched, and we are not compromising that in any way. That is the point I was trying to make earlier.

There is also the reliability of launching on time, and that is the one that you just brought up. That has decreased because of a lot of factors.

One is that we have tightened up our constraints, but also if we had beefed up the structure on the orbiter even more, we would have an increased reliability of launching on time.

Mr. NAGLE. When you talk about reliability, I can substitute the word "safety"?

Dr. FLETCHER. Only for the first aspect. We are not compromising reliability or safety in any of the things that we have done. We are only talking about increasing the reliability of launching on time. It has nothing to do with safety.

Mr. NAGLE. But it is the safety that has narrowed the window?

Dr. FLETCHER. Because of the increased attention to safety, that has narrowed the window of opportunity, that is correct.

Mr. NAGLE. Thank you very much.

Mr. NELSON. Let me say to the committee that we are just about to have a vote on the floor, and I would like to turn to the rest of the committee for any questions that they might have, and it would be my intention to try to wrap up the hearing before we go to the floor to vote.

Mr. Buechner.

Mr. BUECHNER. I think the reference on the 18-minute window—I have got a copy of the environmental impact statement on reliability, and it indicated in support of the upcoming Galileo that they thought the overall reliability of the Shuttle was one failure in 168 launches. The ASRM/AQA thought it was safer to say 78 launches. Other estimates have been down to one in 33.

I guess what I am wondering is, with that in mind, have you done any reconsideration of the mixed fleet concept in terms of maybe we ought to be using a Titan III/Galileo; we don't need a manned unit to do that?

And I look at TDRSS. We could have probably done that, too.

~~Now,~~ I bring that only to mind because I thought that we were talking about a mixed fleet policy, and I just want to know where you are going, and I know that it is a delicate question but I would like you to just kind of elaborate on it.

Dr. FLETCHER. It is not a delicate question. It is a very serious question, and it relates to Mr. Nagle's earlier questions.

When we have a narrow window like we do on the planetary launches, typically three or four weeks, expendables are a better way to go because we aren't then worried about the safety of astronauts, and so in the long term we have signed up to a mixed fleet.

In fact, we plan to have the option of launching the Mars Observer mission on a Titan IV, or a Titan III actually.

In the case of the Galileo there are no available expendable launch vehicles. We could not find either a Titan III that would work, and the Titan IV was not available.

So to wait until we had an expendable launcher available for the Galileo, I have forgotten how many years—two years, and that program started when I was here the first time.

That was one of the projects that I started, and it has been too long already. I think it would be a tragedy if we waited on that particular one another two years.

Mr. BUECHNER. I yield back my time to the gentle lady if she has got any questions or to you, Mr. Chairman.

Mr. NELSON. Any further comments or questions from the committee?

Mrs. MORELLA. I was going to ask other questions, but we can put them in the record.

We are going to miss you, Dr. Fletcher.

Thank you for sending me the materials on the personnel problems, and I wonder whether or not we should in the future consider senior management making a commitment for a said number of years in order to be able to hold them once we get them.

Dr. FLETCHER. I think—by the way, Mrs. Morella, I really feel that you have done a heroic job trying to save the SES system, and I certainly hope Congress signs up with something soon because we are going to lose a lot of people.

The idea of requiring them to serve a period of time I had not thought about, but it is worth considering.

Mrs. MORELLA. We are all working together. A number of other people have been involved in it, and I know NASA has been involved, because it does affect this committee in terms of where NASA is going and the National Science Foundation and a lot of the other groups that we are very much involved with.

I think we are succeeding. Thank you very much, and thank you, Mr. Chairman.

Mr. NELSON. Mr. Skaggs.

Mr. SKAGGS. I did not want to pass up the opportunity to throw a bouquet at Dr. Fletcher either in his last days. I really came to listen to Mr. Nagle. [Laughter.]

That is always enlightening. He wasn't even here to hear me. I did notice——

Mr. BUECHNER. He doesn't come to hear us. [Laughter.]

Mr. SKAGGS. Is that on the record, Mr. Buechner?

Mr. BUECHNER. Whatever.

Mr. SKAGGS. I notice in your statement some encouraging comments about progress on the external tanks utilization, particularly the conclusion of an MOU with U-CAR. I am wondering if you could elaborate on that very briefly as to when you see actual operations taking place to make use of that inner tank space on the ET.

Dr. FLETCHER. Yes, I would be glad to start, but I am going to ask Jim Rose to give you the latest on that.

Mr. NELSON. Let me interrupt here. We have Mr. Rose coming before us, before the committee, and we are going to have a hearing on exactly that subject.

Mr. SKAGGS. Great.

Mr. NELSON. So let's just take that at the appropriate time.

Any further questions or comments, Mr. Skaggs?

Mr. SKAGGS. Thank you, Mr. Chairman. I yield back.

Mr. NELSON. Well, Dr. Fletcher, we thank you and we wish you well in the private sector. Again, there is a great deal of heart felt gratitude. You have had to endure many pressures that an Administrator of NASA should not have had to endure, and that is a testimony to your ability and to your leadership, and we thank you and we wish you godspeed.

Dr. FLETCHER. Thank you, Mr. Chairman.*

Mr. NELSON. The committee is adjourned.

[Whereupon, at 11:52 a.m., the subcommittee was adjourned, subject to the call of the Chair.]

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*Appendix 5 contains CBO Analysis of NASA Commercialization Initiatives. See p. 1156. Appendix 6 contains additional answers to questions asked of Dr. Fletcher following this hearing of Mar. 23, 1989. See p. 1172.

1990 NASA AUTHORIZATION

TUESDAY, APRIL 4, 1989

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, DC.

The subcommittee met, pursuant to recess, at 2:33 p.m., in room 2325, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. **VOLKMER** (acting Chair). The subcommittee will come to order.

I am going to begin the hearing in the absence of our chairman, who is on his way, who is returning from the funeral of our former colleague, former Congressman Chappell, in Florida. The plane is now landing at Andrews and he will be here in a few minutes. When he arrives he can assume the Chair.

I will review his statement and go through that and then we will hear from our witnesses.

During the next two days we will shift gears somewhat in our authorization hearings on the fiscal year 1990 budget request for NASA. In our hearings thus far this year we have heard primarily from representatives of the administration. Today and tomorrow we will be reviewing testimony from experts from outside the Administration.

The witnesses today are drawn from prominent professional engineering and scientific communities. Tomorrow we will hear from senior space policy officials who are now in private life.

We are delighted that all of these organizations and individuals have given so generously of their time to meet with us and to share their views on the current budget request and the overall scope and direction of the civil space program.

As we are all aware this will again be another tough budgetary year for NASA. The testimony from these witnesses will be very useful to this subcommittee when we sit down to mark up the NASA authorization bill.

The witnesses who are with us today are: Dr. Jerry Grey, Director of Science and Technology at the American Institute of Aeronautics and Astronautics; Mr. Theodore Simpson, Chairman of the Aerospace Research and Development Committee of the Institute of Electrical and Electronic Engineers; and accompanying Mr. Simpson is Mr. Richard Gould, chairman of the ACTS Task Force of the Institute of Electrical and Electronic Engineers; Mr. Lawrence Mattson, Chairman of the Aerospace Division of the American Society of Mechanical Engineers; and Dr. Patricia Reiff, member of the Steering Committee of the Space Science Working Group of the Association of American Universities.

On behalf of the chairman I would like to thank these witnesses for being with us today and for the testimony that they will be providing.

At this time I will recognize the gentleman from Wisconsin for his opening remarks.

Mr. **Sensenbrenner**. Mr. Chairman, first of all I would like to ask unanimous consent that we permit photography of this hearing pursuant to committee rules.

Mr. **Volkmer**. Without objection.

Mr. **Sensenbrenner**. Mr. Chairman, during the last month we have had considerable opportunity to discuss one version of where NASA is headed with its fiscal year 1990 budget request. It has been a helpful and thorough discussion of many of the issues addressing this country's space program, but it has been speaking with only one voice, out of necessity, the voice of OMB.

Today and tomorrow we have the opportunity to hear from many voices with many distinct views and priorities. From my review of the testimony submitted we also do not appear as constrained by the budget situation as we may have previously thought. It appears that there are many programs worthy of our support but only one or two which do not make the grade. I am assuming this phenomenon is an expression of confidence by today's witnesses in the leadership of this subcommittee to make the hard choices. Mr. Chairman, I congratulate you.

Often in the course of authorizing various science programs under the jurisdiction of the Science Committee we hear about the need for Congress to allow science proposals to be selected by the peer review process. Today's witnesses fulfill this same need for the subcommittee in that they are independently reviewing the fiscal year 1990 budget request from the administration.

During last week's recess I had the opportunity to meet with many representatives of the aerospace industry who expressed a wide variety of opinions on the needs of the space program. I hope today's discussion will be as rewarding.

I welcome today's witnesses to this hearing and look forward to their testimony.

Mr. **Volkmer**. I thank the gentleman from Wisconsin for those remarks.

Before we begin I think I would like to advise all of our witnesses that your statements will be made a part of the record in full as you testify, at the time you testify, in the record. You may either summarize that statement or you may review it in full, however you so desire, but I have been advised by staff that you have been requested to keep your statements to approximately 10 minutes.

Dr. Grey?

STATEMENT OF DR. JERRY GREY, DIRECTOR, SCIENCE AND TECHNOLOGY POLICY, AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

Dr. **Grey**. Thank you, Mr. Chairman.

I will accede to the chairman's request and summarize the high points of our statement and I assume that the full statement will be included in the record.

Mr. **Volkmer**. Yes, it will.

Mr. **Grey**. Thank you very much, sir.

The advent of a new administration offers us the opportunity to both consolidate our past successes and to forge a new and vibrant United States civil space program.

First on the agenda is a national commitment to U.S. goals in space. First, we do not need any more studies. A number of excellent studies have already been conducted and are available. The AIAA has contributed to this process, incidentally, by setting forth three broad goals in a recent position paper. That is a short position paper, Mr. Chairman; I would like to ask that it be made a part of the record, also.

Mr. **Volkmer**. Without objection, it will be made a part of the record.

Mr. **Grey**. Thank you.

[The paper follows:]

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THE CIVIL SPACE PROGRAM: AN INVESTMENT IN AMERICA

An AIAA Position Paper

Approved by the
AIAA Public Policy Committee
and the
AIAA Board of Directors

October 1988

American Institute of Aeronautics and Astronautics
370 L'Enfant Promenade, S.W.
Washington, D.C. 20024
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A strong civil space program is a key element in economic competitiveness, international prestige, national security, and improving the human condition. Investments in the civil space program are investments in America. They promote economic growth and bring a high return in jobs and increased federal revenues to help support essential government services. Moreover, the civil space program is the most visible global symbol of American technological leadership and has long been one of the most popular federal programs.

Despite the current serious and valid concerns about the U.S. federal deficit, therefore, a national commitment to a healthy civil space program is necessary, along with the budget stability and growth needed to sustain it. Without such a commitment, the nation's position as a world power will suffer. Other countries, despite their own financial stresses, recognize the value of space investments and have made commensurate long-term commitments to broadly based space programs.

The U.S. has lost much ground in recent years from its former dominant position in virtually every area of space endeavor. However, American space leadership, with all it implies, can be reaffirmed if the nation makes a commitment to pursue the following goals:

1. Expand our current efforts to understand the Earth, the near-Earth environment, the Sun, the Solar System, and the distant universe.

2. Enhance the competitiveness of U.S. industry in launch vehicles and space applications such as satellite communications, navigation, and Earth observations as well as in space-related services, information, and eventually products.

3. Extend human presence beyond a permanently occupied Earth-orbiting space station to the Moon and Mars.

Prerequisites to the achievement of these goals include comprehensive research programs, broadly based technology advancement and demonstration efforts, long-term commitments to infrastructure development, construction, and operations, assured access to space via a full range of reusable and expendable vehicles, and substantial investments to update and improve education in science and engineering. Further, the importance of U.S. space activities to national well-being requires an independent, authoritative national space policy body with direct and timely access to the President.

The AIAA has recommended that a growth in civil space program support to about 1.3% of the overall federal budget is needed for reasonable progress toward achieving the proposed goals and their prerequisites. However, we recognize the powerful deficit-reduction pressures imposed on the formulation of annual budgets, and we acknowledge the unfortunate fact that these pressures may compromise vigorous pursuit of the above-stated goals. There are, however, overriding concerns that must be kept in mind when such compromises are being considered:

1. The space technology base is the foundation on which all future space activities and capabilities depend. Support for that base must not be allowed to decay, even though much of its payoff will come in the future.

2. Completion of current programs, both in science and in infrastructure development, should generally take precedence over the introduction of new programs. Once a program is approved and initiated, it should be completed on schedule and on budget. Program delays and stretch-outs always increase costs, often reduce capability, motivation, and accomplishment, and must be avoided.

3. Cutbacks in research, technology and advanced development spending must be avoided if they will result in substantially higher development or operations costs later. The goal is to minimize overall life-cycle costs.

The goals proposed herein do require a sustained budgetary commitment but are not costly relative to other federal investments in the nation's future. Most citizens recognize and applaud the commitment to the small fraction of the federal budget that supports the civil space program. The acknowledged urgency of reducing federal deficits must not impose a crippling constraint on the future generations who will reap the benefits of the space-program investments we make today.

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Mr. **Grey**. Those three goals are: to expand our understanding of the Earth and universe; to extend human presence beyond Earth orbit, to explore the solar system; and to create a profitable space industry.

What is needed now is a national commitment to these or similar goals and a firm slate of objectives designed to achieve them along with commensurate long-term program and budget commitments.

In the pursuit of these goals we have suggested three guidelines. These are not new—we offered them to you last year—but we believe they are worth repeating:

First, do not allow support for the technology base to decay. It is our investment in the future and we cannot afford to let that happen.

Second, we should complete our current programs, once they are committed, on time and on budget. Stretchouts are always costly and must be avoided wherever they show up.

And finally, do not cut up-front costs—that is, development costs—if such costs will increase the overall program life-cycle costs. Too often short-term considerations will weight our future descendants with extra costs that could be averted if we invest properly early in the program.

I would like now to turn to the specific comments on the fiscal year 1990 NASA budget proposal, and I will limit my remarks here in accord with the chairman's request to just a few of the many points that have been made in the written statement.

First, we believe the budget proposal, for the most part, is consistent with the achievement of the goals we have espoused. However, it is the minimum budget required to do so. Reducing it, despite the strong deficit-reduction pressures, would seriously compromise our ability to pursue an acceptably balanced U.S. civil space program.

First, let's look at access to space. Creation of a single national space transportation program from among the various efforts discussed in my statement is essential. We need assured, low-cost, reliable access to space for both human crews and unmanned payloads. The mixed fleet, thank goodness, is now a reality. But it needs a great deal of ordering to reach its objective.

Decisions must be made very soon on the shuttle's evolution and those decisions must be integrated into the next-generation transportation development, which is currently called the Advanced Launch System.

My written statement describes the various options and also suggests some specific actions to encourage our still-budding commercial space transportation industry.

On the space station, a space station is essential to every long-term plan that has been proposed. In keeping with our guidelines, now that we have made the commitment to develop that station, we must proceed at full speed.

I have quoted the late President Kennedy on the Apollo program. His words are most appropriate to the space station today: If we are to go halfway, better not to go at all, unless we are prepared to bear the burden to make it successful.

We have already made that decision. The space station should be brought on-line at the earliest practical date.

With regard to technology, it is too easy to postpone spending on the development of future capabilities. But again, as our guidelines state, this temptation must be strongly resisted. Our space technology bank has been depleted and must be replenished.

Of NASA's two new technology programs, the Civil Space Technology Initiative, which deals with nearer term requirements, appears budgetarily healthy, but Pathfinder, whose purpose is to advance the techniques needed for our longer term space exploration goals, has suffered. Not only is the current budget proposal inadequate, but we hope you will also seek restoration of the previous year's reduction from the original Pathfinder plan, and a much-needed supplement to the budgeted amount that has been given to the Office of Exploration for its excellent activities. Without the requisite technologies, plans for any long-term exploration of the solar system become no more than idle dreams.

The Space Science Board's long-term plan cannot be faulted, but its fulfillment requires consistent, multi-year commitments. The new start proposed this year, the Comet Rendezvous Asteroid Flyby and Cassini mission, is particularly critical, not only for its exciting scientific promise but because of its unique economic, international, and management approach.

The critical timing of these missions should also be noted. If we are to pursue them at all, we have no margin for procrastination.

The CRAF-Cassini missions, incidentally, and, even more forcefully, the upcoming Galileo flight to Jupiter, underscore the serious state of our space launch situation. It is truly deplorable that we must rely on devious and intricate, although admittedly brilliant, gravity-assist maneuvers to conduct these missions, adding years to their durations, instead of the fast, direct trajectories that could be offered by a properly capable launch vehicle family.

In commercial programs, there has been much rhetoric, as well as a number of proposals that range from the practical to the visionary, on commercial space development. We have in our statement identified six potential areas for such developments, and we have proposed a slate of government actions to encourage that development.

A comprehensive paper on the subject is currently being reviewed by the AIAA for release. If and when that release is approved by our board, I will be pleased to provide copies to the subcommittee and also to brief your staff on its content.

Although often neglected in the urgency of the budget process, science and engineering education are the props that uphold our civil space program and, indeed, the entire economy of our ever more technocratic society. My statement calls attention to the need for major upgrading of our science education in the United States, with the space program serving as an important lever in that process.

Of all the subjects we have covered in our statement—and, as I said, many of these I have not covered in this brief summary, but they are included in the full statement—there are three that stand out as being most essential to the space future of the Nation: the development of new technology, the pursuit of a broad and balanced science program, and the rapid development and deployment of Space Station Freedom.

These programs, along with the transportation capability needed to carry them out, are the underpinnings for all of our space goals. I hope your subcommittee will champion in the Congress the urgency of sustaining the new administration's strong budgetary support for these critical areas and, indeed, will seek some growth in those areas whose budgets we believe are still somewhat deficient.

If there is any way the AIAA can help in that regard, please call on us.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Grey follows:]

AIAA
American Institute of Aeronautics and Astronautics

STATEMENT TO THE
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES

ON THE

FISCAL YEAR 1990 NASA BUDGET PROPOSAL

BY

JERRY GREY, DIRECTOR, SCIENCE AND TECHNOLOGY POLICY
AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS
WASHINGTON, DC

APRIL 4, 1989

370 L'Enfant Promenade, S.W. ■ Washington, D.C. 20024-2518 ■ Phone: (202) 646-7400 ■ FAX: (202) 646-7508

INTRODUCTION

The American Institute of Aeronautics and Astronautics (AIAA) is a nonprofit professional society dedicated to advancing the art, science, and technology of aeronautics and astronautics and to promoting the professionalism of those engaged in these pursuits. We have a membership of over 40,000 drawn from all levels of American industry, academia, private research organizations, and government as well as from numerous nations abroad.

For many years the Institute has emphasized the importance of a strong civil space program for advancing science and technology, improving the human condition, and maintaining this nation's international prestige, national security, and economic competitiveness. Investments in the civil space program promote economic growth and therefore increase the federal revenues needed to support essential government services.

The U.S. today is faced with ever-increasing competition from foreign governmental, commercial, and pseudo-commercial space ventures which are heavily subsidized by their governments. The next decade will determine how well the U.S. is able to meet that competition. Despite serious and valid concerns about the federal deficit, spending cuts aimed at reducing near-term budget pressures can have a devastating impact on our ability to achieve long-term goals designed to maintain our economic, political, and scientific leadership in the modern world.

The advent of a new administration offers us a unique opportunity to begin the new decade by reshaping the American space program to meet both the technological and the political challenges of the 21st century, not the least of which is the high-profile Soviet space program. In 1961, the United States space program faced a similar challenge from the Soviet Union. On May 25 of that year, President Kennedy delivered this message to the American people:

> "Recognizing the head start obtained by the Soviets with their large rocket engines, which gives them many months of lead-time, and recognizing the likelihood that they will exploit this lead for some time to come in still more impressive successes, we nevertheless are required to make new efforts on our own. For while we cannot guarantee that we shall one day be first, we can guarantee that any failure to make this effort will make us last."

America's response to President Kennedy's challenge brought us the outstanding success of Apollo and unquestioned global leadership. A comparable commitment now to national long-term goals could make 1990 the first watershed year for America's civil space program.

The AIAA has formulated three such goals for a national space policy:

(1) Expand our current efforts to understand the Earth, the near-Earth environment, the Sun, the Solar System, and the distant universe.

(2) Extend human presence beyond a permanently occupied Earth-orbiting space station to the Moon and Mars.

(3) Enhance the competitiveness of U.S. industry in launch vehicles and space applications such as satellite communications, navigation, and Earth observations as well as in space-related services, information, and eventually products.

This final goal can be restated more explicitly: create a profitable space industry, which in turn will stimulate private sector investments, maintain and improve U.S. global economic competitiveness, generate economic benefits for the U.S. populace, and enhance the quality of life on Earth.

The Institute has also noted that achievement of these goals will require comprehensive research programs, broadly based technology advancement and demonstration efforts, long-term commitments to infrastructure development, construction, and operations, and assured access to space. Substantial investments are also required to revitalize and improve the quality of U.S. education in science and engineering at all levels.

These goals and the prerequisite activities needed to achieve them are not costly relative to other federal investments in the nation's future. However, we recognize the powerful deficit-reduction pressures imposed on the formulation of annual budgets, and we acknowledge the unfortunate fact that such pressures may compromise vigorous pursuit of the above-stated goals. We urge that when considering such compromises you keep in mind these overriding guidelines:

(1) The space technology base is the foundation on which all future space activities and capabilities depend. Support for that base must not be allowed to decay, even though much of its payoff will come in the future.

(2) Completion of current programs, both in science and in infrastructure development, should generally take precedence over the introduction of new programs. Once a program is approved and initiated, it should be completed on schedule and on budget.

Program delays and stretchouts always increase costs, and often reduce capability, motivation, and accomplishment; such delays must be avoided.

(3) Cutbacks in advanced research, technology, and development spending must be avoided if they will result in substantially higher development or operations costs later. While lower front-end costs may seem attractive in an austere budget environment, planning objectives must focus on minimizing overall life-cycle costs.

We believe the FY 1990 budget proposed by the administration is for the most part consistent with pursuit of the long-term goals espoused by the AIAA and with the three above-stated guidelines. Our views on the detailed programs within that budget are as follows:

SPACE TRANSPORTATION

Safe, reliable, and timely access to space is essential for a successful U.S. space program. We applaud the return of the Shuttle to flight status, but urge the expansion of efforts to establish a mixed fleet of expendable and reusable launch vehicles, both government and commercial, that can both meet growing U.S. launch needs and compete with ever more capable and numerous foreign launch operators.

With the Shuttle's return to flight status, the proposed increased funding of the Orbiter's extended-duration on-orbit capability makes good sense; even more extensive improvements may be required in the future if the Shuttle is to continue to serve us over the next few decades. In consonance with the funding guidelines noted earlier, we strongly support the proposed significant increase in space research and technology activity aimed at improving our ability to transport payloads, both in orbit and from the Earth's surface into space. Current R & D in this area should be focused on improving the reliability and lowering launch and overall life-cycle costs for transportation systems. In addition to NASA research and technology programs, the current Advanced Launch System (ALS) development effort by the DOD and NASA will avoid duplication of activities and ensure the most efficient use of government resources.

However, the requirements for space-station deployment beginning in the mid-1990s will impose a transportation demand on the Shuttle which has been identified by the National Research Council as its foremost concern in the entire space-station program. One alternative is the development of a Shuttle-derived unmanned cargo vehicle, Shuttle-C, able to loft as much as 150,000 lbs. per flight into low-Earth orbit. This interim capability, although clearly not a substitute for the ALS because of its high recurring cost and limited operational flexibility, could help to alleviate the heavy Shuttle manifest in the mid to late 1990's, thereby reducing the chances of a Shuttle mission failure during space-station deployment. Although such a vehicle would require some additional budget commitment for development of the unmanned payload carrier to replace the orbiter, there is a possibility that some of that investment would be made by the private sector if NASA were able to make a commitment to purchase the necessary number of Shuttle-C launches. If for no other reason, the relatively high probability of a Shuttle mission failure sometime during the next decade at projected launch rates warrants serious consideration of the Shuttle-C alternative.

With or without a Shuttle-C commitment, however, upgrading of the Shuttle's reliability through the use of advanced boosters is needed. NASA has recognized this need by initiating an Advanced Solid Rocket Motor (ASRM) development and also by conducting a Liquid Rocket Booster study. One of these alternatives should be implemented in time for space station deployment in the mid-1990s if possible. Development efforts in this area should focus on providing a smooth transition to next-generation launchers such as ALS and advanced Shuttle designs.

It is also necessary to look beyond the Shuttle and even ALS technologies toward future space transportation systems that are more cost-effective and reliable. We must begin developing the technologies now that will enable such a system and designing the incentives that will drive us toward it. The AIAA applauds this Subcommittee's action last year in supporting the joint NASA/DOD effort on R & D for the hypersonic National Aerospace Plane.

The government can also lend its support to the budding U.S. commercial launch industry and thereby ensure the availability of a robust mixed-fleet capability by emphasizing the importance of purchasing required launch services wherever possible and by not competing with commercial firms for nongovernment payloads. The AIAA applauds the recent Commercial Space Launch Act Amendments, which go a long way toward minimizing insurance barriers to commercial launch activities. Future legislation could address additional concerns such as the availability of affordable first-

and second-party insurance. These measures, along with continued effective regulatory reform, will support U.S. industry's ability to develop the world's lowest-cost, most capable, and most reliable launch service system.

Other actions which will facilitate the development of a broad "mixed fleet" transportation capability include ensuring that the minimum number of operationally available Shuttle orbiters is maintained at four, investing in advanced technology areas critical to the development of next-generation vehicles, and expanding the use of cooperative industry-government instruments such as Joint Endeavor Agreements (JEAS) and Space System Development Agreements (SSDAs) to encourage the upgrading of commercial expendable launch vehicles.

Efficient in-orbit transportation is also essential to low-cost space operations. The AIAA therefore supports the requested budget increase for the orbital maneuvering vehicle (OMV), which can both extend the Shuttle's capabilities and play an important role in the deployment and operation of Space Station Freedom. We also see the need for intensive technology development leading to a new, fully reusable high-energy upper stage for future geocentric operations, lunar and Mars exploration, and missions to the outer planets.

SPACE STATION FREEDOM

A space station is an essential feature of almost every long-term space plan proposed in the past two decades. Because the development and deployment of Space Station Freedom will require a significant fraction of NASA funding during the next decade, it will be a prime target for spending cuts in the constrained budget environment of the coming years. However, it is imperative that this program receive support at the level requested in both the current NASA budget proposal and the multiyear authorization approved by this Subcommittee last year. The costs of building, deploying, and operating Space Station Freedom will be repaid many times over through the economic, social, and political benefits it will provide to this country.

Space Station Freedom will restore U.S. leadership in manned space and provide a source of international prestige and national pride in which all Americans can share. It will also continue and strengthen the U.S. tradition of international cooperation in space. We have already signed agreements with our allies in Japan, Europe, and Canada, receiving from them commitments both to develop Station elements and to provide substantial financial support.

The unique space environment of Freedom's laboratories will make it possible to conduct space science research and technology development that cannot be performed on Earth, in astronomy, astrophysics, space applications, space processing, and biomedical and life sciences research. Station facilities will enable us to conduct zero-g experiments of unprecedented length and complexity, providing valuable data and experience for extended duration human space exploration. It will serve as an observatory for critical biospheric Earth processes and augment the Earth observation capabilities developed through Mission to Planet Earth activities. Freedom will provide critical support to the U.S. manned space program by facilitating advanced instrumentation research, serving as a platform for the assembly and launching of deep-space transport vehicles, and providing a base from which to conduct in-space servicing activities. The Space Station is an integral element in any future exploration strategy, whether the final destination is the Moon or Mars.

Commercial space development in the U.S., vital to future economic competitiveness and trade (as has been recognized by all the other spacefaring nations), will be much strengthened by the access of U.S. industry to a permanent in-space experimental facility. Space Station Freedom will facilitate research on new processes and products, and on technologies such as future-generation supercomputers, space sensors, pharmaceutical products, and instrumentation.

Because the Station will be in operation for decades, operations assessments must be funded and infused into the program at an early stage. The recommendations of NASA's Space Station Operations Task Force (SSOTF) are aimed at reducing the costs of space station operations and encouraging industrial participation; they should be implemented expeditiously.

The AIAA concurs with the National Research Council's finding that the current space station design is the appropriate one, and we believe, further, that the funding requested is indeed the minimum required to fulfill Freedom's mission requirements. In that context, President Kennedy's historic 1961 announcement of the Apollo program is again especially pertinent:

> "If we are to go only half way, or reduce our sights in the face of difficulty, in my judgment it would be better not to go at all...But I think every citizen of this country as

> well as the Members of the Congress should consider the matter carefully in making their judgment, to which we have given attention over many weeks and months because it is a heavy burden, and there is no sense in agreeing or desiring that the United States take an affirmative position in outer space, unless we are prepared to do the work and bear the burdens to make it successful. If we are not, we should decide today and this year. "

This philosophy is exactly in accord with our above-stated guidelines. The AIAA therefore enthusiastically supports this Subcommittee's unprecedented action last year in authorizing multi-year budgeting for the space station, which allows the cost savings that accrue from proper management of long-term commitments and planning. The current practice of partial or phased funding within a budget year is especially devastating to the orderly management and budget control of any development program that extends over almost a decade. Indeed, rather than cutting funds and slowing down the program, now that it has been approved Congress should direct NASA to get Space Station Freedom on line at the earliest practical date. It is indecision we cannot afford.

HUMAN EXPLORATION

As noted earlier, we consider exploration to be one of the most important national goals of the U.S. civil space program. However, we believe that extension of human presence beyond low Earth orbit should proceed methodically rather than with an Apollo-type "leap." We commend the efforts of NASA's Office of Exploration in formulating "exploration strategies" for future missions to the Moon, Phobos, and Mars. Regardless of the final destination selected, however, extensive planning, precursor missions, and advanced development must be part of the mission planning process. Priorities must be established at the outset and pursued in an orderly manner throughout the entire process.

However, long-term exploration research and planning efforts must receive proper funding if we intend to be one of the leaders in future space endeavors. The FY 90 budget request for NASA's Office of Exploration (Code Z) is inadequate to provide the strong base required for any large-scale exploration undertaking, although the office's performance to date with the limited funds available has been outstanding.

In addition to a strong planning base, human exploration missions will require a more complete understanding of how living systems react to the stresses of space flight. We commend NASA for proposing an FY 90 budget adequate to sustain a forward-looking, balanced program in the life sciences, especially the focus on the 1.8-m centrifuge and long-duration crew operations. These and other space-station programs, along with elements of the Pathfinder initiative, are essential to the planning for human exploration of the Moon and Mars. The stretchouts necessitated by last year's Pathfinder program budget cuts should be recovered by increased funding this year in these key areas. We also support the continuation of the joint programs with the Soviet Union on analyzing long-duration space flight and sharing data on space biology and medicine. However, we would like to emphasize the importance of maintaining a balance between scientific and technology efforts; the Life Sciences program must be supported by in-space research and experimentation.

SPACE SCIENCE

The U. S. space science program is a national resource. It requires the aggressive pursuit of worthy goals and a strong commitment to their attainment, to draw talented new people into the field and keep them there.

Planning for space science is the most thorough and comprehensive of all NASA activities. The AIAA strongly supports the long-term program delineated in the recent Space Science Board's six-volume plan, and urges the use of multiyear commitments for these programs to ensure the stability necessary for projects measured in decades rather than years. In that context, we deplore the proposed cancellation of the Gravity Probe B program.

We commend NASA for adhering closely to the Office of Space Science and Applications Strategic Plan, key near-term elements such as the Great Observatories Program (Hubble Space Telescope, Gamma-Ray Observatory (GRO), Advanced X-Ray Astrophysical Facility (AXAF), and Space Infrared Telescope Facility), the planetary exploration program, and the Earth Observation System. We support NASA's aggressive plans in progress for close observation of several planets, beginning with Magellan (Venus) and Galileo (the Jovian system) and then the Mars Observer.

We urge your support for a new start recommended by NASA's Space Science Board: the Comet Rendezvous Asteroid Flyby (CRAF)-Cassini mission, which seeks to discover how our solar system formed and, as a consequence, how life began. CRAF-Cassini will allow us to examine the primordial remnants left by the formation of the planets, frozen in time more than four billion years ago in the comets and planets of the outer solar system.

CRAF will rendezvous with the comet Kopff and accompany it during part of its orbit around the Sun. It will send a penetrator/lander into the comet's nucleus, provide the first direct data on a comet's chemical composition, and offer the first close-up look at how a comet's tail of dust is formed. On its way to the comet, CRAF will encounter an asteroid: 449 Hamburga, taking photographs and other scientific measurements.

Cassini will orbit Saturn, providing extensive observations and conducting mapping of its rings, moons, and magnetosphere. It will also send a probe into the dense atmosphere of Titan, which will provide unique data on processes there which are similar to those in the pre-biotic atmosphere of Earth.

CRAF-Cassini will be the first in the Mariner Mark II Spacecraft class. Mariner Mark II will use hardware and designs from previous missions in conjunction with selected new hardware designs to reduce significantly the cost of both missions. NASA has made an admirable effort to save millions of dollars by combining these two missions, which would cost an additional 0.5 billion if pursued separately. Thus CRAF-Cassini should not be separated and considered on an either/or basis. In addition to the cost-savings inherent in the CRAF-Cassini new start, it has the added attraction of being an international project. European commitments to CRAF-Cassini represent savings to NASA of hundreds of millions of dollars in the development of Cassini's Titan probe and in additional science instruments and propulsion modules.

A new start is strongly favored at this time because CRAF-Cassini is a "perishable" opportunity in several respects. First, ESA's financial commitments are substantial, and the agency's selection process is such that they cannot wait another year. Further, the baseline launch windows are in 1995 (CRAF) and 1996 (Cassini). A delay of 1.5 years in the Cassini launch would result in a two-year delay in its arrival at Saturn and the loss of valuable Jupiter fly-by science. A delay for CRAF would be particularly serious because any subsequent development delay could add about 4.5 years to the trip time. Thus, an FY 90 new start provides a much-needed "cushion."

The Explorer and suborbital programs historically have been the proving grounds for innovative ideas in physics and technology and have provided for the application of advanced technologies to current research areas. They have produced most of the currently available information on the ionosphere and magnetosphere, and have served to attract students to space science research and to help them develop expertise in this area. These programs also serve the important function of testing new instruments and technologies prior to their application to larger and more expensive missions. We strongly support this Subcommittee's multiyear procurement philosophy that would extricate funding for these small to medium scale projects from the vagaries of year-to-year funding by authorizing their budgets for periods of at least three years.

The increases proposed for mission operations and data analysis are absolutely necessary to cope with the unprecedented influx of new data and information expected from new spacecraft such as Galileo, Magellan, Ulysses, the Hubble Space Telescope, the Gamma Ray Observatory, the Roentgen Satellite, the Cosmic Background Explorer, and Mars Observer. In addition, funding should be allocated to develop new, advanced methods of handling, accessing, and analyzing this stream of data. Full funding is needed to implement NASA's plans in this area.

MISSION TO PLANET EARTH

The Institute strongly supports the Subcommittee's mandate to NASA to implement the Mission to Planet Earth by 1993; indeed, the recently recognized seriousness of current environmental changes warrants an even earlier system availability. It is not too soon to begin taking the initial steps toward that goal, such as accelerating instrumentation development for the Earth Observation System (EOS). The abovementioned global environmental trends -- the increase in atmospheric carbon dioxide, depletion of the stratospheric ozone layer, and the widespread effects of acid rain and other forms of air pollution -- underscore the urgency of helping to characterize environmental phenomena through space-based observations. The EOS, when complete, will give the best and most comprehensive analytical view ever of Earth as a total system.

SPACE TECHNOLOGY

Technology advancement heads our list of overriding guidelines on funding decisions. Last year we deplored the reductions in FY89 funding for the Civil Space Technology Initiative (CSTI) and the Pathfinder program, particularly the massive cuts in the latter. Although we are pleased to see an acceptable increase in the CSTI request this year, the proposed level for Pathfinder funding continues to be wholly inadequate. Sustained support for CSTI, and especially the long-term commitment required for the Pathfinder program, are fundamental to the future of the U.S. manned space program. We cannot pursue human solar system exploration as a national goal without the advanced technology derived from these programs, both of which will provide major returns in both civil and commercial space sectors.

Although budgetary pressures often result in substantial R&D base cuts, it is precisely during such challenging times that technology advancement can at least keep us in the game and, indeed, may be the most cost-effective way of doing so. We urge that you adamantly support and retain these truly critical programs.

SPACE COMMUNICATIONS

The U.S. still maintains world leadership in supplying commercial communication satellites, but that lead grows more and more precarious as foreign firms, supported by their governments at annual levels measured in hundreds of millions of dollars, develop advanced communications technologies. During the initial successful development of the commercial communications industry, NASA took responsibility for advanced technology and subsequently transferred operations to the private sector. Although the market has now reached maturity (and indeed initial government investments have been returned many times over in industry tax revenues), it is still appropriate for NASA to carry out new and high-risk systems development.

To help sustain U.S. leadership, NASA in recent years has focused its space communications R&D effort on the Advanced Communications Technology Satellite (ACTS) program. While many communications payload capabilities are being developed by the private sector, the critical high-risk technologies represented in ACTS, such as large antenna structures, hopping beams, and advanced on-orbit message processing, have not yet reached the point where their development is commercially viable. NASA must continue to support R&D for future communications technology areas until U. S. commercial interests can assume responsibility for system development, application, and marketing.

COMMERCIAL PROGRAMS

The AIAA applauds the administration's 1988 policy espousing private-sector involvement in space. However, although we endorse NASA's efforts to develop private-sector links via the Centers for Commercial Development of Space and the creation of multi-user, multi-use government hardware, much more can and should be done.

Opportunities for commercial space development exist in at least six areas: satellite communications (currently a mature industry, as discussed earlier), Earth observations, space processing and research applicable to ground-based manufacturing, life sciences, transportation, and ground and orbital services. Although commercialization will be accomplished by the private sector, not the government, the high cost and risk of space ventures and their clear potential for U.S. economic growth call for a strong government commitment to the support of commercial space development. That support consists not only of funds for research, technology advancement, and demonstration (as with the ACTS program cited above, for example), but also of purchasing (rather than providing) goods and services required by the government, not competing with the private sector for provision of goods and services to others, and incentivizing private-sector investment; for example, through cost and risk reduction mechanisms and more flexible regulatory requirements. The government can also support U.S. industry in tapping world markets, and can encourage rather than discourage collaborative mechanisms among industry, government, and academia wherever they would improve U.S. competitiveness with foreign government-supported organizations worldwide.

If NASA takes the lead in developing facilities for industry research leading toward space commercialization, as was done decades ago with wind-tunnel facilities, the initial investment will be returned by the development of new, prosperous industries. At this stage, however, industry cannot be expected to undertake the full investment alone.

The microgravity environment of space can be used to conduct research that could improve ground-processing capabilities, evaluate space processing, and lead eventually to space manufacturing. However, the risks, costs, and time required for a company to return an acceptable profit on investments in space capabilities are all far greater than those of ground-based investment alternatives. Dependable access to low-cost space R&D facilities is currently the most serious obstacle to the pursuit of the research needed to reduce the risks.

To alleviate this problem, the AIAA has advocated expanded use of Spacelab and other Shuttle-borne facilities, and commends NASA's decision to augment the Orbiter's on-orbit duration. In addition, by deploying the Space Station Freedom on schedule, NASA can perform the space R & D that will enable space commercialization, just as NACA wind tunnels supported the commercial aviation industry. The AIAA supports the future use of a Commercially Developed Space Facility (CDSF) to supplement Station Station Freedom activities and to help create a favorable environment for commercial space activities in the latter half of the 1990's. However, CDSF capabilities do not in any way warrant its consideration as a substitute for the Space Station; indeed, near-term CDSF activities should focus on identifying R & D projects for the Space Station which could eventually lead to profitable CDSF experiments and operations.

Additional prospects for near-term commercial space projects and privatization efforts should continue to receive careful consideration. For example, an innovative concept which might prove successful is the recent proposal by the National Academies of Science and Engineering to privatize the operations of several NASA centers or to transfer their management to universities, although such actions may not be appropriate for some time. NASA must carefully plan its course before embarking on efforts to privatize its operations.

In this vein, the AIAA wishes to comment on the provisions in the current proposal for $208 million in private financing for NASA projects. Dr. Fletcher himself has expressed some reservation about whether NASA will be successful in securing these funds, particularly for "higher-risk" items such as the Flight Telerobotic Servicer (FTS) and the Space Station Docking Module. There has been a notable absence of concurrence on this issue by industry, and until this is forthcoming, NASA should be prepared to provide alternative funding options for these projects.

SCIENCE AND ENGINEERING EDUCATION

The decline in U.S. science and engineering education in recent years is a source of considerable concern to the AIAA. Although projected near-term defense budget cutbacks could defer significant problems for the next few years, a strong pool of talented young engineers is a critical element for future American technical and economic competitiveness. Since 1973 the enrollment of foreign nationals in U.S. engineering graduate programs has more than doubled. Today, less than half (about 40%) of the engineering students at the doctorate level in the United States are U.S. citizens. NASA is particularly vulnerable to the diminishing availability of engineers - within two years almost 70% of NASA's 2500 top senior and mid-level managers will become eligible for retirement.

Engineering education suffers not only from limited enrollment but from the poor preparatory training many students receive at the pre-college level. The results of recent studies comparing the various levels of ability in basic science and math skills among students in several countries send a strong message: we are failing to provide adequate education to our students in these areas. The U.S. cannot continue to finish last if we wish to remain internationally competitive technologically, economically, or intellectually Radical new approaches to pre-college science and math programs, such as that recently proposed by the American Association for the Advancement of Science and other scientific organizations, will certainly contribute to national efforts to get U.S. scientific educational programs back on track.

We believe that the space program can help stimulate renewed interest in science and engineering, by showing students that technical careers can be exciting, interesting, and rewarding. University research activities are strengthened by programs such as CSTI and Pathfinder, which provide graduate students the opportunity to become knowledgeable and to gain hands-on experience in challenging areas of space technology. We support the increased funding proposed for important programs such as the NASA/USRA/University Advanced Design Program, the Space Engineering Research Center Program, and the Space Grant College and Fellowship program. Future efforts to stimulate student interest in space should include students at the pre-college level as well. Space Station Freedom will help to replenish the youthful enthusiasm for science and mathematics that was so evident during the Apollo era, but has sadly diminished in recent years.

CONCLUSION

The AIAA has consistently called for a balanced program of civil space activities, but does not presume to tell the administration or the Congress how to manage individual elements of the civil space program.

We believe, however, that the civil space program today finds itself at a particularly critical juncture in its 30-year history. Recovery from the Challenger failure, the surging growth of overseas capability and competitiveness, the serious economic consequences of the federal budget deficit, the need to replenish our decades-old store of technology, and the recognition of potentially irreversible global environmental changes all call for an unprecedented focus on the role of space in the future of humanity. In addition to the general guidelines we have offered for dealing with the expected pressure to reduce budget deficits, therefore, we believe it appropriate to point out the potentially serious consequences to the nation's space posture of stretchouts or budget cuts in three critical NASA program areas: space technology advancement, space science and applications, and the space station.

The technologies on which our current space activities depend are based largely on NASA programs of the 1960s and 1970s. Many foreign space programs, which began to mature later than those of the U.S., incorporate commensurately more advanced technologies, and are therefore positioned to move more effectively into the 1990s and the 21st century. Investments in technology are relatively easy to postpone, because their payoff is in the future. Such postponements must be resisted, however, because they mortgage our future capabilities, upon which depend our future economic health, our national prestige, and to a considerable degree our national security.

In this context, also, NASA has been subject to much recent criticism for its failure to make commitments to challenging goals in space exploration such as manned missions to Mars or its moons or returning to the Moon. To achieve goals of this scope, however, will require years of dedicated attention to the multitude of technology advancements needed to conduct such imaginative missions. Again, it is all too easy to scrimp on investments in these technologies, despite their relatively low levels, simply because their payoff is so far in the future. But unless we do make those investments and sustain them on a multiyear basis, there is little hope that the spacefarers who eventually do explore the Solar System will be U.S. citizens.

Space science is the base on which our entire civil space program rests. Its funding support does not necessarily have to be huge, but it must be stable and consistent. Most space science programs span one or more decades; the vagaries of year-to-year "crises," whether political, societal, or economic, are anathema to such activities. Nobody can fault the long-term planning for space science; it is perhaps the best to be found anywhere in the U.S. government. That planning should be supported on a long-term, consistent basis that recognizes the need for precursor programs and applicable technology development.

A space station is the single common element (other than transportation) in almost all long-term space plans. Without it, as with a sustained investment in technology advancement, exploration of the Solar System by U.S. astronauts would be extraordinarily difficult if not impossible. The Space Station Freedom's design has been subjected to exhaustive reviews. In one of the more recent of these, the National Research Council concluded that the presently conceived station design cannot be materially improved with current knowledge. Foreign governments have committed nearly $8 billion to its development and deployment. It will provide a permanent human presence in space, along with the infrastructure needed to support future space exploration, Earth observations, orbital servicing, microgravity research and eventually processing, commercial development, life science experiments essential to long-term human activity in space, and development of future space capabilities. Stretchouts and delays can only increase its life-cycle cost and reduce its long-term effectiveness.

Thank you for this opportunity to present our views on the civil space program. We will do our best to answer any questions you may wish to ask.

BIOGRAPHY BRIEF FOR DR. JERRY GREY

Dr. Jerry Grey received his Bachelor's degree in Mechanical Engineering and his Master's in Engineering Physics from Cornell University; his PhD in Aeronautics and Mathematics from the California Institute of Technology.

His early career included stints as full-time Instructor of Thermodynamics at Cornell, engine development engineer at Fairchild, Senior Engineer at Marquardt, and hypersonic aerodynamicist at the GALCIT 5-inch Hypersonic Wind Tunnel. He was a professor in Princeton University's Department of Aerospace and Mechanical Sciences for 15 years, where he taught courses in fluid mechanics, propulsion, and nuclear powerplants and served as Director of the Nuclear Propulsion Research Laboratory. He formed the Greyrad Corporation in 1959 and was its full-time President from 1967 to 1971; from 1976 to 1982 he was Adjunct Professor of Environmental Science at Long Island University. He was Publisher of Aerospace America from 1982 to 1987, and is now Director of Science and Technology Policy for the American Institute of Aeronautics and Astronautics, consultant to a number of government and commercial organizations, and a Director of the Applied Solar Energy Corporation.

Dr. Grey is the author of twenty books and almost three hundred technical papers in the fields of solar energy, space technology, aerospace policy, fluid dynamics, heat transfer, rocket and aircraft propulsion and power, plasma diagnostics, instrumentation, and the applications of technology. He has served as consultant to the U.S. Congress (as Chairman of the Office of Technology Assessment's Solar Advisory Panel), the United Nations (as Deputy Secretary-General of the Second UN Conference on the Exploration and Peaceful Uses of Outer Space, 1982), NASA, the Department of Energy, and the U.S. Air Force, as well as over twenty industrial organizations and laboratories. He was Vice President, Publications of the AIAA for five years, Chairman of the Coordinating Committee on Energy of the American Association of Engineering Societies, and President of the International Astronautical Federation. He is currently a member of the Department of Transportation's Commercial Space Transportation Advisory Committee, a Director of the Scientists Institute for Public Information, a Fellow of the Explorer's club, and a member of the Office of Technology Assessment's Space Transportation Advisory Panel.

Dr. Grey is listed in Who's Who in America, Who's Who in Aviation & Aerospace, Engineers of Distinction, Contemporary Authors, American Men of Science, Men of Distinction, National Register of Prominent Americans, Who's Who in Technology Today, International Who's Who in Energy & Nuclear Sciences, The Writer's Dictionary, Blue Book, and Dictionary of International Biography. His most recent book, Beachheads in Space, was published by Macmillan in May, 1983, following his widely acclaimed book on the space shuttle, Enterprise (William Morrow).

Mr. Volkmer. Thank you very much, Mr. Grey.

Mr. Simpson?

STATEMENT OF THEODORE R. SIMPSON, CHAIRMAN, AEROSPACE R&D COMMITTEE, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, ACCOMPANIED BY RICHARD G. GOULD, CHAIRMAN, ACTS TASK FORCE, IEEE

Mr. Simpson. Thank you, Mr. Chairman and the subcommittee.

I am speaking today on behalf of the U.S. Activities Board of the IEEE. The IEEE, or, as it is also known, the Institute of Electrical and Electronics Engineers, is the world's largest technical society. It has more than 300,000 members worldwide, of which more than 240,000 reside in the United States.

After I complete my statement of the Fiscal Year 1990 NASA budget and the future of the space program, my co-speaker, Rick Gould, will discuss our opinions on the ACTS program.

First, I would like to discuss what we like about the proposed Fiscal Year 1990 budget. We like the recent trend in the NASA budget. Since the Apollo 11 flight 20 years ago, NASA's program has gone into relative stagnation until the Challenger accident. At that point in time, the Nation woke up to the realization that its program was in serious jeopardy, and since Challenger, funding for NASA has increased substantially. We support that funding, and we think it is necessary to maintain leadership in space.

We like the overall distribution of the Fiscal Year 1990 budget. It is a balanced budget. It considers not only of aeronautics but space as well, and the subcategories within it. We support not only manned space flight but also "Mission to Planet Earth" and the unmanned exploration of the universe, and we think that they are equally important.

We support the Space Shuttle's funding. We are glad to see that the Space Shuttle has had three successful flights since Challenger and that, during Fiscal Year 1990, there will be nine successful flights. The Space Shuttle is the key to our manned space flight program. Without it, nothing else can be done.

We also support funding for the Space Station Freedom. It will allow us to live permanently in space to work there and will be needed to explore the solar system in the 21st century. It is the next key step after the Space Shuttle.

We also are glad to see that there are several new starts in the budget both in aeronautics and space. In aeronautics, we support the high-speed civil transport. If it is developed downstream, it will allow us to get from Los Angeles to Tokyo in 3 to 4 hours.

In space, we are glad to see that there are two unmanned solar system missions: Cassini, which will explore Saturn and its moons, particularly Titan; and CRAF, which will give us new information about comets and asteroids.

There are several things that we do not like about the proposed NASA budget. One thing that we would like to comment on about the need for our future in space: We need a long-term goal for manned space flight. The Space Shuttle and the space station are means, not ends. What is the job to be done? This is not a new question that has been asked; it is something which has been around since the decision to build a Space Shuttle back in 1970. The National Commission on Space discussed this; so did Sally Ride's report to the Administrator in 1987.

We think that NASA's goal during the 21st century in manned space flight should be the exploration of the solar system. Following in NASA's footsteps should be private industry, which should build large permanent settlements in space when they become economically viable.

Thus, the Federal Government's long-term goal in space should be to spread human life throughout the solar system in the 21st century. We do not look at this as something which should be a crash program but rather something which is steady and evolutionary in definition during the 21st century. First we build a Space Station during the 1990's; then we should return to the Moon and then go on to Mars.

Twenty years ago, man first walked upon the Moon.

Twenty years from now, men and women should be permanently living and working on the Moon. Thus, we support the goal of a small base on the Moon in the year 2009.

While Congress and the White House debate the pace, scope, and timing of this evolutionary growth, NASA should continue working on studying options to obtain these goals and developing the technology necessary. Technology is a high-leverage item. It is something which costs little but which will buy you time and capability downstream. You need to make that investment now in order to avoid wasting time or limiting your capabilities in the 21st century.

While NASA's budget was cut during the 1970s to one-third of its peak during the 1960s, the space technology part of NASA was cut to one-fifth of its size during its peak at the Apollo program. The National Commission on Space in 1986 said that funding for space technology should increase from 2 percent to 6 percent. A year later, in 1987, the National Research Council advocated increasing the budget for space research and technology from 2 percent to 7 to 10 percent.

In reviewing the proposed Fiscal Year 1990 budget, we found that the space research and technology part of it was 2½ percent. Looking further, we saw that money for Pathfinder had been lagging both in the 1989 and the 1990 budget. We advocate adding about $50 million to the 1990 budget for the Pathfinder program in order to develop the technology and the mission studies necessary for manned and unmanned solar system missions in the 21st century.

At this point, I would like to turn the testimony over to Rick Gould, who will discuss the ACTS program in particular and also the future of communications satellite R&D at NASA.

[The prepared statement of Mr. Simpson follows:]

STATEMENT TO THE
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

ON THE
PROPOSED FY 1990 NASA BUDGET

BY

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AND

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APRIL 4, 1989

Institute of Electrical and Electronics Engineers
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Good afternoon Mr. Chairman and members of the Subcommittee. My name is Theodore Simpson, Chairman of the IEEE Aerospace R&D Committee. I am accompanied today by Richard Gould who is Chairman of our ACTS Task Force. We are speaking on the proposed FY 1990 NASA budget on behalf of the IEEE United States Activities Board.

The IEEE is the world's largest technical society with more than 300,000 members worldwide, of which, more than 240,000 reside in the United States.

I. SUMMARY AND RECOMMENDATIONS

First, we would like to tell you what we like about the proposed budget, and then discuss its shortcomings. In particular, we believe that there is a need for:

1. A long-term goal for manned space flight,
2. Increased funding for space technology, and
3. Continuing the Advanced Communications Technology Satellite (ACTS) program.

What We Like About the Proposed FY 90 NASA Budget

After the Apollo 11 landing twenty years ago, NASA went through a long period of relative stagnation until the Challenger accident, when the nation woke up to the fact that our federal space program was in decline. Since the accident, NASA has received substantial increases in its annual budget. We have and continue to support these increases because they are necessary to maintain U.S. leadership in aeronautics and space.

With a few exceptions, discussed below, we also like the overall distribution of funding within the proposed FY 90 NASA budget. It is very important that NASA's budget be balanced so that both aeronautics and space receive their proper share of the-funding. And, it is equally important that within these two major categories that the various subcategories receive a reasonable share of the funding.

For example, while manned spaceflight is a major part of NASA's space program, it is not the only part that should be advanced. Sally Ride's "Mission to Planet Earth," and the unmanned exploration of the universe are equally important.

We are glad to see that the Space Shuttle has recently successfully completed its third flight, and that during FY 90 there will be nine shuttle flights. The Space Shuttle is one of the key elements of our manned space program. Without it, the program would grind to a halt, as we have seen during the past three years.

Another key element of the manned space program is Space Station Freedom. We believe that this should also receive adequate funding since it will enable us to permanently live and work in space and to explore the solar system.

We are also glad to see that NASA will initiate work on new programs in both aeronautics and space.

In aeronautics, it will perform a series of environmental studies which could eventually lead to the development, in 10 to 20 years, of a prototype high-speed civil transport. Such an aircraft could fly at a speed of Mach 2-3.5, and carry passengers from Los Angeles to Tokyo in 3-4 hours.

In space, work will begin on two unmanned solar system spacecraft -- Cassini and the Comet Rendezvous Asteroid Flyby (CRAF). These spacecraft will advance our understanding of the solar system's origin and perhaps uncover clues to the origin of life as well.

What We Don't Like About the Proposed NASA Budget

Mr. Chairman, NASA needs a clear focus for its manned space program. Since the Apollo 11 landing, twenty years ago, it hasn't had it. Both the Space Shuttle and Space Station Freedom are "means," not "ends." They are tools to be used for a job. What's the job?

We believe that NASA's goal in this area should be a slow, but steady, exploration of the solar system during the 21st Century. Eventually, private industry should follow in NASA's footsteps and establish large, permanent settlements when they become economically viable. Thus, the long-term goal of the Federal Government's civil space program should be to spread human life throughout the solar system.

As the first step in this process, we should build a Space Station during the 1990s. This will allow us to permanently live and work in space. Second, we should consider extending the Station's capabilities at the turn of the century so that it could become a spaceport in Earth orbit. This would allow us to send Americans back to the Moon and build a Lunar Outpost there by 2009.

Twenty years ago, man first walked on the Moon. Twenty years from now, men (and women) should permanently live and work there. The Moon, like the space station, will be a great training ground for our eventual next step, a manned mission to Mars.

During the 1990s, while the President and Congress debate the scope and pacing of the various milestones for manned spaceflight, work should proceed at NASA on studying various mission options and on developing the space technology that will be needed to accomplish them. After Apollo 11, NASA's budget for Space Research and Technology was slashed to about one-fifth of its value at its peak in 1965.

We believe that about $50 M should be added in this area during FY 90 for the Pathfinder program. In comparison with the total NASA budget, this is a small amount. However, space technology is a high-leverage item that will allow us to keep our future manned and unmanned space exploration programs on track. Without this funding, we will lose a significant amount of time downstream when this technology is needed for operational systems.

Satellite communications has grown from its inception 25 years ago to an important U.S. industry, generating several billion dollars annually. The growth of this new industry resulted from what history has shown to be a wise Government-Industry satellite communications technology development policy. Research and flight demonstration programs were sponsored, for the most part, by NASA during the first decade of the space age.

Commercial satellite communications is the best -- and so far the only -- example of a new industry created from space technology.

But satellite communications is more than an industry. It is a technology that has brought the world closer together through better communications. Satellites bring news from around the world into American homes as it happens: from wars to the Olympics to summit meetings -- wherever they take place. In the other direction, satellite communications is being used by the U.S. Information Agency to carry the Voice of America, and TV programs of its World Net service to other countries. Satellite communications has helped trade, industry and international understanding by providing economical voice and data communications between countries around the world.

Now, satellite communications is reaching out to users with smaller and smaller terminals. Search and Rescue satellites developed under NASA sponsorship pick up distress messages from downed airplanes and ships in distress. A new multi-billion dollar industry is about to be launched as a direct result of NASA's communications programs. A commercial U.S. Land Mobile-satellite system will be operated by a consortium of companies to provide two-way telephone communications to trucks and trains -- as well as planes and ships -- using terminals only a little larger than today's automobile cellular radio telephone sets. This new industry and service is the product of more than 15 years of NASA development programs and user experiments that have cost from one to three million dollars a year. It should prove to be one of the most important telecommunications initiatives in decades in terms of economic payback and commercial and public sector applications.

But the IEEE is concerned that the substantial financial, social and political benefits which have been derived from the creation of a satellite communications industry may wither and be lost, because of sharply curtailed NASA communications technology development programs. Without this new and improved technology, irreparable harm will be caused to this profitable and promising industry. This space-based business is now facing intense competition from several foreign government-industry space consortia.

Specifically, the IEEE is concerned that there is no strong government commitment to continuing NASA satellite communications development programs -- including the Advanced Communications Technology Satellite (ACTS) program itself. Each program year the continuation of the ACTS program hangs in the balance. Each year, the Congress comes to its rescue and the work continues.

We recommend that the U.S. Government continue the mandate given to NASA by a previous Congress in the Space Act (Public Law 98-361), to "seek and encourage, to the maximum extent possible, the fullest commercial use of space." We urge this Congress to take two steps so that NASA can continue to carry out that mandate:

- Continue support of the Advanced Communications Technology Satellite (ACTS) program by including $61.4 M funds in the NASA FY-90 budget to continue construction of the spacecraft, and $4.5 M for the first year of an experiment and demonstration program.
- Direct NASA to develop, and bring to the Congress for approval, a continuing program for the development of satellite communications technology, which will exploit the unique properties of satellites, i.e., access, with wide bandwidths providing a variety of signals and services to large numbers of fixed and mobile users with small, inexpensive terminals. These developments will improve the declining competitiveness of the U.S. satellite communications industry, provide the public with lower cost telecommunications, and help conserve the precious -- and limited -- resources of the electromagnetic spectrum and the geostationary satellite orbit.

II. A LONG-TERM GOAL FOR MANNED SPACE FLIGHT

On this coming July 20th, we will celebrate the twentieth anniversary of the most important single event that has occured so far in our space program -- the landing of the Apollo 11 crew on the Moon. It will be a day of celebration and of sadness.

It will be joyful because we will recall what great things that we Americans can accomplish when we set our minds to do them and we work together as a team. President Kennedy was correct when he said that: "It will not be one man going to the Moon ... it will be an entire nation."

July 20th will be a sad occasion as well, because we will inevitably reflect upon all that could have happened in the exploration of space over the past twenty years if we had been able to maintain the momentum generated by the Apollo 11 mission. If we had, the first Americans would have already trod on the sands of Mars and returned to Earth.

As shown in Figures 1 and 2, from 1967 until 1974, NASA's budget was continually cut until it was reduced to only one-third of its peak funding in 1966. With such a cutback, any hope for maintaining the momentum of Apollo evaporated.

NASA's budget was never a large piece of the total Federal budget, and from 1975 until the Challenger accident in 1986, NASA's budget was less than one percent of the total Federal budget.

If NASA is to maintain its present program, scale and pace, its funding will have to be increased during the 1990s. This is not only our opinion but that of others as well. In May 1988, the Congressional Budget Office (CBO) issued a report, The NASA Program in the 1990s and Beyond, that stated that the NASA budget would have to rise to $14.4 B (1988 dollars) by 1993, and to $16.4 B (1988 dollars) by the year 2000 to do a core space program.

Such a core program was described by CBO as a middle of the road approach which could continue the existing space projects, such as the Space Shuttle and Space Station Freedom, but did not include any funding for a new lunar or martian manned space initiative. Such an initiative, CBO stated, could "...more than triple" NASA's current real budget by the year 2000 to about $30 B (1988 dollars) per year.

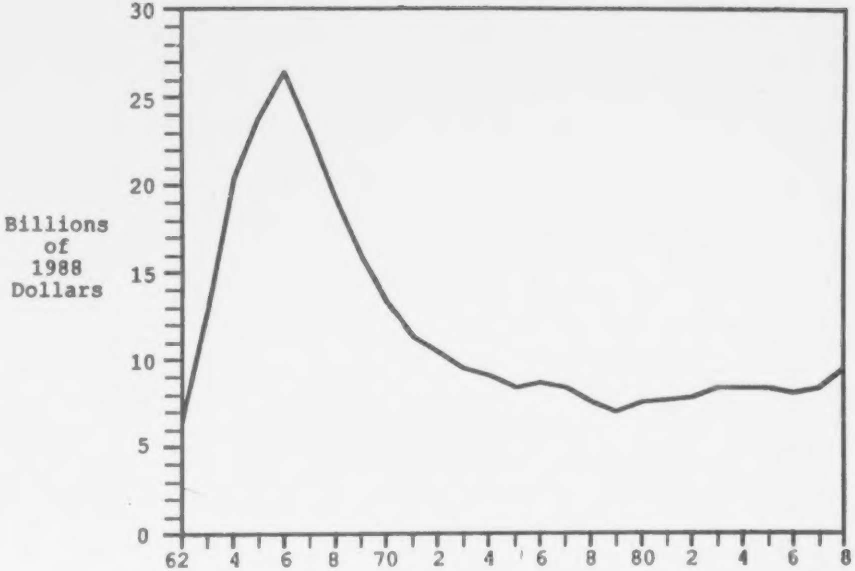
In view of our past history in space, our current position, and the importance of our federal civil space program to our nation's future, we urge the Congress to give thoughtful consideration to such an increase for NASA. And we are heartened by the support Presidents Reagan and Bush, and the Congress, for increasing NASA's budget since the Challenger incident. The proposed FY 90 NASA budget will raise NASA's percentage of the proposed FY 90 Federal budget to 1.14 percent.

However, money alone will not solve NASA's problems. What it needs is a long-term goal for its manned space program. Without it, some of this increased funding will inevitably be wasted.

Such a goal was provided by the National Commission on Space (NCOS) in 1986 in its report, Pioneering the Space Frontier:

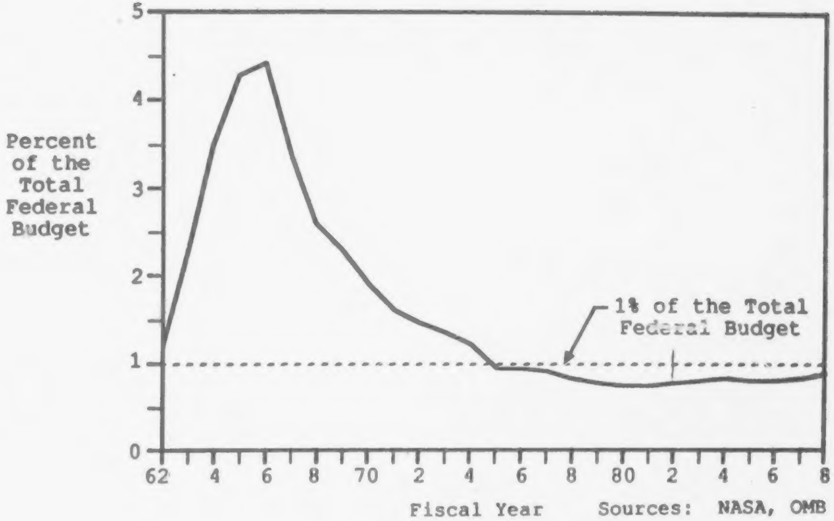
> "To lead the exploration and development of the space frontier, advancing science, technology, and enterprise, and building institutions and systems that make accessible vast new resources and support human settlements beyond Earth orbit, from the highlands of the Moon to the plains of Mars."

President Reagan supported this goal in January 1988 in his national space policy statement which stated that the long-term goal of the civil space program was " ... to expand human presence and activity beyond Earth orbit into the solar system."



Sources: NASA, OMB

Figure 1
NASA Funding (Outlays FY 62-88)



Sources: NASA, OMB

Figure 2
The NASA Budget as a Percentage of the
Total Federal Budget (Outlays FY 62-88)

NCOS not only defined the long-term goal in 1986, it also described a series of evolutionary steps to achieve it. First, the United States should permanently occupy Earth orbit and expand its scope of activities there. Then, we should return to the Moon, and in the year 2005, set up a small Lunar Outpost there. Finally, in the year 2015, the first Americans should land on Mars.

This evolutionary approach was subsequently supported by Dr. Sally Ride in her 1987 report, Leadership and American's Future in Space:

> "We should explore the Moon for what it can tell us, and what it can give us -- as a scientific laboratory and observing platform, as a research and technology bed, and as a potential source of important resources. While exploring the Moon, we would learn to live and work on a hostile world beyond Earth. This should be done in an evolutionary manner, and on a time scale that is consistent with our developing capability.
>
> "The natural progression of human exploration then leads to Mars. There is no doubt that exploring, prospecting, and settling Mars should be the ultimate objective of human exploration. But America should not rush headlong toward Mars; we should adopt a strategy to continue an orderly expansion outward from Earth."

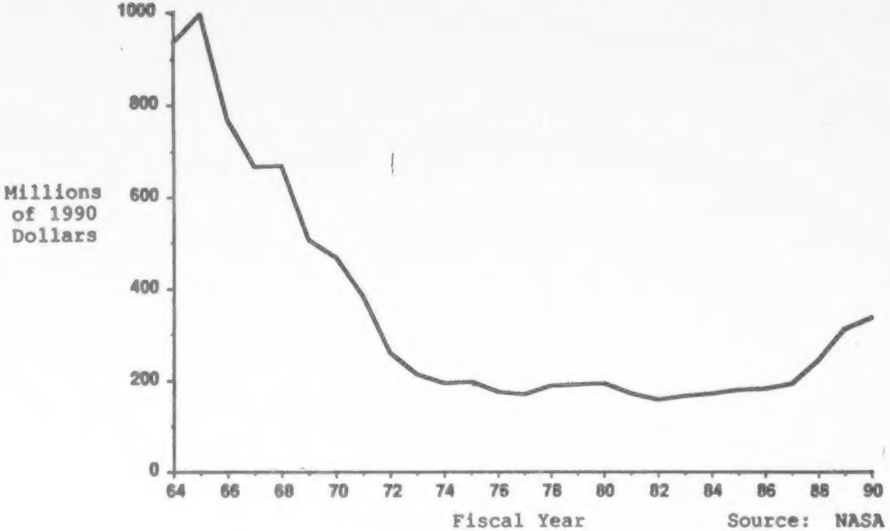
What is now needed is for the President to propose, and the Congress to approve, a specific series of milestones like those proposed by NCOS. Without such a series of concrete objectives, the United States could waste a lot of money and ultimately lose its leadership in manned spaceflight.

III. INCREASED FUNDING FOR SPACE TECHNOLOGY

In anticipation of a decision to return to the Moon and then go to Mars, NASA has begun to restore its technology base.

As shown in Figure 3, NASA's funding for Space Research and Technology declined form about $1,000 M (1990 dollars) in 1965 to about $200 M (1990 dollars) in 1973 and remained at about that level until the Challenger accident. In other words, while the overall NASA budget was slashed to one-third of the peak funding after the Apollo program ended, the budget for Space Research and Technology was slashed to about one-fifth its peak funding after Apollo.

To overcome this deficiency, NCOS recommended that the budget for Space Research and Technology be tripled -- from two percent of NASA's overall budget to six percent. A subsequent report by the National Research Council in 1987, Space Technology to Meet Future Needs, recommended that the budget for Space Research and Technology be increased to seven to ten percent of the total NASA budget. In the proposed FY 90 NASA budget, funding for Space Research and Technology is $338 M, or 2.5 percent of the proposed $13.274 B total NASA budget.



Source: NASA

Figure 3
NASA's Funding For Space Research and Technology

Thus, if it is at all possible, we would like to see this amount increased in the FY 90 budget by about $50 M. We recognize that this will be a difficult year to do this, but the development of the technology needed to increase our exploration and use of space is a high-leverage item. In comparison with the rest of the NASA budget, its cost is low, but it must be done now or we will lose a great deal of time or capability later on when the operational space systems are built.

Over the past few years, NASA has started two major programs in the Space Research and Technology area:

1. The Civil Space Technology Initiative (CSTI) program was begun in FY 88. Its primary emphasis is on efficient, reliable access to, and operations in, low Earth orbit, and on supporting science missions from Earth orbit.

   CSTI has three major thrusts:

   a. Transportation - to improve the capability of the Space Shuttle, to do the initial research for the next generation of launch vehicles, and to develop an aerobrake for the space transfer vehicle (STV). The STV, which is not yet an approved NASA program, could be based at the space station and be used to transport humans and cargo to higher Earth orbits and the Moon.

   b. Operations - to develop our capabilities in robotics, autonomous systems, and high capacity power for Earth orbit operations. this will allow us to gradually expand the scope of our manned and unmanned activities in earth orbit.

   c. Science - to improve the capability of our sensors and the data rate/capacity of the data links transmitting scientific data back to the Earth; and to develop the capability to assemble and control large, flexible structures in Earth orbit.

2. The Pathfinder program was begun in FY 89. Its primary emphasis is on developing critical capabilities to enable future missions of solar system exploration, both manned and unmanned.

   Pathfinder has five major thrusts:

   a. Surface Exploration - to enhance future manned and unmanned missions on the Moon and Mars by developing the technology needed for: 1. planetary rovers, 2. soil sample acquisitions, analysis and preservation, 3. autonomous landers, 4. surface power, and 5. hybrid photonic/electronic equipment for high data rate communications and processing.

b. In-Space Operations - to enhance space operations associated with the exploration of the solar system by developing the technology needed for: 1. autonomous rendezvous and docking, 2. in-space assembly and construction, 3. a cryogenic fluid depot for a space-based STV and other vehicles, 4. space nuclear power, 5. a pilot plant to process lunar and martian rocks and soil to obtain oxygen, and 6. optical communications between the Earth and the Moon and Mars.

c. Humans-In-Space - to define requirements and develop technologies that will enable or significantly enhance future manned missions to explore the Moon and Mars, including: 1. spacesuits, 2. developing the means to counter the effects of long-term weightlessness and natural radiation on human performance in space, 3. physical/chemical closed-loop life-support systems, and 4. bioregenerative closed-loop life-support systems.

d. Space Transfer - to develop the technology needed for space transfer vehicles that will be used for manned exploration of the solar system, including: 1. chemical STVs, 2. aerobrakes, and 3. nuclear/electric cargo vehicles.

e. Mission Studies - to develop several options for: 1. the exploration of the Moon and Mars, 2. precursor unmanned missions to Mars, and 3. unmanned mission to the outer planets.

Funding for Space Research and Technology (in-then year dollars), during the five-year period from 1986-1990, is given in Table 1.

Table 1

NASA's Funding for Space Research and Technology
(Millions of Dollars)

	1986	1987	1988	1989	1990
CSTI	0	0	115.2	121.8	144.5
Pathfinder	0	0	0	40.0	47.3
Other	0	75.4	0	0	16.2
R&T Base	151.4	130.6	108.4	134.1	130.1
Total	151.4	206.0	223.6	295.9	338.1

In the FY 89 NASA budget approved by the Congress last November, CSTI was reduced by $35 M from the level requested in January 1988 by President

Reagan; and Pathfinder was reduced by $60 M from the amount requested. The R&T Base was not reduced.

Based upon our analysis of the funding for the R&T Base, CSTI, and Pathfinder, both the R&T Base and CSTI appear to be in good shape. Pathfinder, on the other hand, since it is the newest program, is having trouble getting off the ground.

In the proposed FY 90 budget, last December, the White House reduced NASA's request of $100 M for Pathfinder by $52.7 M. Clearly, this trend should not be allowed to continue if the United States is serious about being a world leader in the exploration of space.

NASA has estimated that it will need about $750 M during the five-year period from 1989-1993 to adequately fund Pathfinder. We support this funding and believe that, in FY 90, funding for Pathfinder should be increased by about $50 M. This would allow NASA to speed up work in some existing areas, and to initiate work in the following five areas: 1. hybrid photonic/electronic equipment, 2. a pilot plant to process non-terrestrial resources, 3. optical solar system communications, 4. crew protective systems, and 5. cargo vehicle propulsion.

IV. CONTINUING THE ACTS PROGRAM

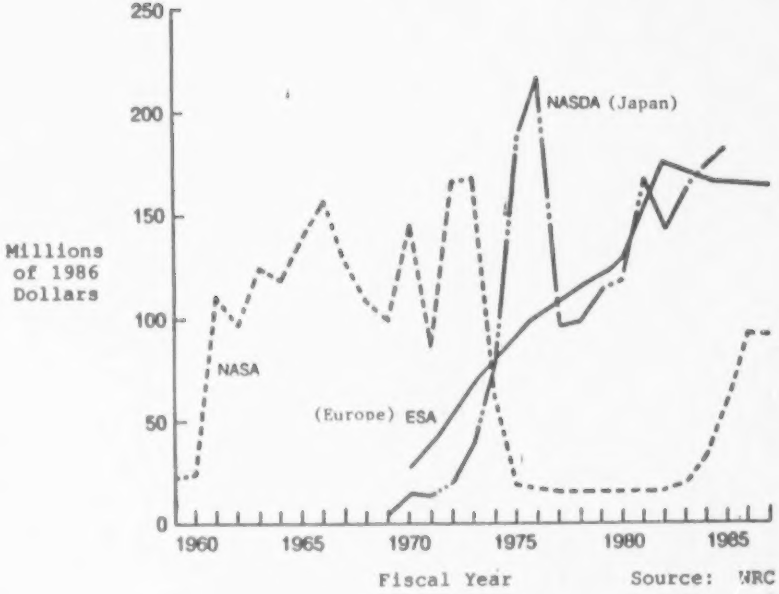
Telecommunications has a history of always going higher -- higher in altitude, higher in frequency, higher in power and higher in performance.

Telecommunications engineers reach for these superlatives, not because they want to show off technical virtuosity, but because they have to keep pace with the demands. More people in more parts of the world want to communicate with each other, telecommunications requirements grow in size and complexity; lower frequency bands fill up; users insist on better sound and visual quality and demand greater accuracy, availability, and reliability of their transmissions.

Communications satellites, first brought into existence under NASA sponsorship, put radio relay stations at higher altitudes than ever before and made low-cost, worldwide telephone and television possible. Figure 4 shows that NASA funded communications satellite research in the early 1960's, far earlier than other countries.

NASA R&D programs developed equipment and components for high-power broadcasting of television directly to people's homes, and then put up a satellite embodying that technology using a frequency band higher than ever used before in an operational satellite.

ACTS is a good example of a NASA program that will make practical the use of satellites operating at still higher frequencies to provide a new capability



Source: NRC

Figure 4
Annual Funding for Communications R&D Programs

-- simultaneous high-capacity communications transmissions to a multiplicity of terrestrial locations throughout a service area the size of the United States, or even larger. The satellite technology being developed under the ACTS program can also be used for the transmission of television pictures having higher definition, better color rendition, and capable of filling wider screens, than that now being broadcast anywhere in the world. HDTV is the visual equivalent of hi-fi stereophonic sound.

And HDTV is not only for entertainment. Among its many other commercial and government applications, satellite HDTV can be used for remote medical diagnoses and consultation, and for the transmission of "CAT-scans" (Computer Assisted Tomography). These new communications capabilities can bring better medical care to currently underserved areas of rural America.

Following the development of satellite communications technology under NASA sponsorship in the early 1960s, the United States held the lead in the satellite communications business for many years, but -- by any measure -- we have relinquished that leadership. After its abandonment of satellite communications development programs in 1973, the leadership in high-power K_u-band (12 GHz) traveling wave tubes (TWTs, the devices that make direct broadcasting possible) passed to France and Germany. U.S. sales of Intelsat earth stations to other countries, which once made a significant contribution to our GNP, have virtually disappeared. We have also lost revenue from the sale of launch vehicles -- and launch services -- to Europe, Japan, China, and potentially, to the USSR.

Consider the history of spacecraft procurements by Intelsat. The early generations of satellites were entirely U.S. built. The foreign content of Intelsat satellites increased as European manufacturers were added as subcontractors in subsequent satellite generations. Most recently, a European consortium bid as prime contractors for the Intelsat VII procurement. Their proposal was fully compliant, technically attractive and economically competitive. Only the recent decline in the U.S. dollar vis-a-vis European currencies, and some concern by Intelsat over the divided responsibility such a multi-company consortium entailed, saved this important contract for a U.S. company. With competition like this from a fully mature European space industry, a U.S. company may well not win the next Intelsat procurement.

Consider another indication of the loss of U.S. leadership in the satellite communications field: One of the premier technical meetings of the IEEE is our International Conference on Communications (ICCs). At these yearly conferences, engineers describe their significant accomplishments. This year, the Conference will have three sessions on communications satellites. One, on the use of portable earth terminals, has been organized by a Japanese engineer. Three of the papers in that session come from Japan, one from Italy and another from Australia. Only one is by a U.S. author. That paper comes from Jet Propulsion Laboratory, which derives its support from NASA for the ACTS-related research described therein. A second satellite session on advanced satellite communications techniques was also organized by a Japanese engineer. It has two papers from Japan, one from Brazil and two by U.S. authors. The third session was organized by GE Astro, the U.S. company that leads the industry contractor team working to develop, build and test the new ACTS technology, but four of its contributed papers are from Italy, one is from Japan and another from the Netherlands. In sum, only 3 of the 17 papers to be presented in the three sessions originated in the U.S., that is, only about 18%.

We now have an opportunity to reclaim some of this technological and commercial territory.

But the techniques and technology for higher frequencies, faster switching, and wider bandwidths doesn't come easily or cheaply. This higher frequency band is definitely less "user-friendly" than the bands we've been using. For one thing, propagation conditions are worse. Rain and atmospheric gasses cause more loss, which must be overcome by higher power satellites, or through higher efficiency devices.

Not only have the costs gone up, but regulatory changes in the telecommunications industry have made it more difficult for commercial companies to support and participate in ground-breaking programs like ACTS. In the early 1960s AT&T was the only domestic long distance and international telephone carrier. It could justify the cost of its own propagation experiments, its own technology development programs and the cost of two Telstar communication satellites. It could justify the $6 million cost of an earth station in Andover, Maine, for experiments and demonstrations. In the 1960s Comsat was the only satellite carrier and the U.S. signatory in Intelsat. AT&T was the Intelsat System Manager and it could justify the expenses of its extensive laboratories and the fundamental development work performed there.

But times have changed. AT&T is no longer the only domestic and international telephone carrier or the owner of the Bell Operating companies. Comsat is only one of many competing domestic satellite operators. And Intelsat itself has competition from regional satellite systems such as Arabsat, Eutelsat and others, and, potentially, from other international systems being developed in the United States under the "Separate Systems" policy adopted by the FCC.

The new competitive environment described above will benefit both U.S. telecommunications users and the U.S. economy. But there are important side effects. Since a few companies no longer have a monopoly to provide terrestrial and space telecommunications services, most of today's smaller, competing companies do not have the resources to invest individually in expensive research and development programs. At the same time, U.S. antitrust laws prevent or discourage companies acting collectively to fund research and development. (This is a significant factor in our inability to compete, not only in this but in other industries where foreign governments subsidize research heavily or encourage consortiums of companies within industries.)

Under these circumstances, an increasing burden must inevitably fall on the

Government -- which represents all carriers, all manufacturers and all telecommunications users -- if United States interests are to be advanced from now on in the satellite communications field.

Brief History of the ACTS Program Including the Congressional Cap

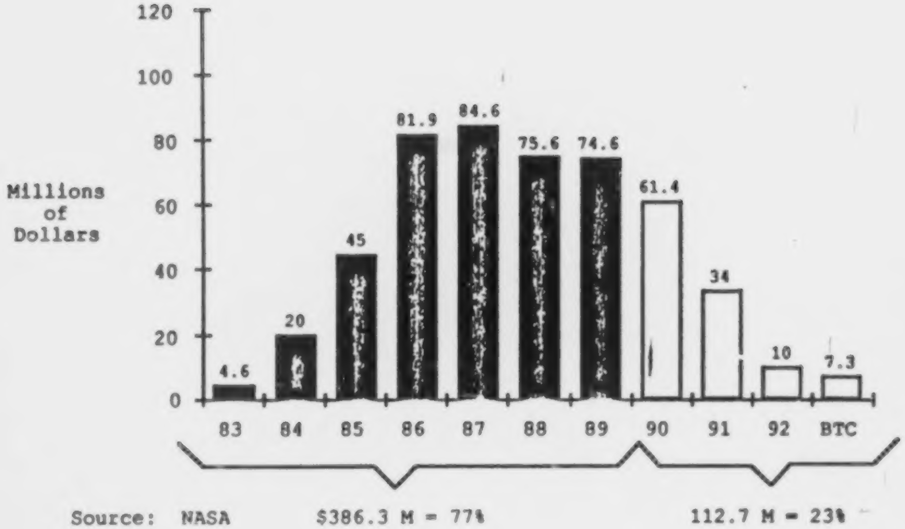
As shown in Figure 5, the ACTS program was begun in 1983. The peak years for expenditures were the four years from 1986 through 1989. With the design and development work almost finished, and the spacecraft on the way to completion, only some 23% of the approved total for the whole program is still to be expended. We believe that Congress should add the $61.4 million to the FY 90 budget for the ACTS program. This would represent about half of the total outstanding funding needed for ACTS.

The ACTS program seeks the development of several new technologies:

- Multiple Beam Antennas - to produce high-powered spot beams enabling communications with small, low-cost earth stations; to permit re-use of the radio frequency spectrum; to permit "hopping" of beams to geographical areas with traffic demands, and to permit those beams to "dwell" on each such location for only as long as necessary to pick up and deliver the traffic.
- On-Board Processing - to improve link performance by demodulation and remodulation on-board the spacecraft.
- On-Board Switching - to switch individual circuits on-the-spacecraft (using baseband processor) that will provide a "switchboard in the sky" and enable efficient communications with thousands of terminals located directly on the customers' premises.
- K_a-Band Technology - to develop equipment and techniques for using a portion of the radio frequency spectrum by communications satellite.

During FY 88, in response to Congressional concern over increases in the cost of the program and delays in project completion, NASA restructured the ACTS program as directed by the Congress. Contractual and management changes were made, giving NASA greater and more effective control over the project. The government, through NASA, took over the role of system manager, with Comsat and GE Astro Space acting as associate contractors.

The Congress also imposed a "cap." With this upper limit on program cost in place, there can be no overruns. Since then, development activities have continued toward achieving the new Space Shuttle launch readiness date of May 1992.



Source: NASA

Figure 5
ACTS Program Funding

The White House Says No, The Congress Says Yes

A funny thing happens on the way to Capitol Hill. Each year, NASA includes ACTS in its budget request to the White House. But each year the ACTS program is missing from the proposed NASA budget by the time it reaches the Congress.

The IEEE is appreciative of the continuing support that the Congress has given to this important endeavor by restoring the funding for ACTS each year. The telecommunications industry specifically -- and U.S. trade and industry in general -- have benefited, and will benefit, from the technology being developed in the ACTS program.

But these yearly cliff-hangers do not inspire confidence among members of the industrial community. Without some measure of assurance that the program will be continued and that the spacecraft will actually be built and flown, potential commercial partners in the experimental program have another reason to hold back from investing in earth stations and other equipment that would permit their participation.

Potential Commercial Benefits of ACTS to the United States

Some explorations are motivated primarily by an academic interest in the unknown, or by a sense of adventure. Sometimes, those motivations produce unintended commercial benefits. Exploration in Alaska reveals oil and exploratory dives to the bottom of the sea reveal nodules of commercially important minerals. But some explorations are driven by need. The need for new land, or the need for a better way to get from here to there.

Exploration of the K_a-band (20-30 GHz) is in the latter category. Requirements for telecommunications are growing. Lower frequency bands are filling up. New services -- gluttons for bandwidth -- are here now or are emerging: for example computer-to-computer communications (including the interconnection of supercomputers), electronic mail, electronic funds transfer, individual and commercial access to the data banks of the world, and the provision of specialized entertainment programming to audiences around the world -- and in wall-to-wall HDTV format. These are some of the many commercial reasons to exploit this band for commercial space-based telecommunications.

We will not be alone in the 20-30 GHz band. Japan, Germany, Italy, France and the USSR have active K_a-band telecommunciations satellite programs.

Japan launched its first K_a-band satellite in 1977. Their current plans for the CS-3 satellite, which is to be launched in 1990, call for onboard switching equipment -- one of the ACTS technologies. A scanning beam capability --another one of the ACTS technologies -- is being considered for their CS-IV satellite, scheduled for launch in 1991. Italy is planning to launch an experimental K_a-band satellite with on-board switching, also in 1991. A recent visitor to Italy confirmed that this program is on schedule and that the satellite will probably be in orbit before the ACTS spacecraft. ESA plans to launch a series of K_a-band Olympus satellites starting in this year, 1989. They will also have onboard switching. While they employ technology encompassed by the ACTS program, these foreign satellites are still less sophisticated than ACTS both at the component and system level. However, the technology gap is closing.

Completing The ACTS Program

There are two elements necessary to complete the ACTS program. Obviously, one element is the completion of the spacecraft itself -- about $112 million, as shown in Figure 5. To date, about 77% of the total program cost previously approved by the Congress has been spent. Of the remaining 23%, $61.4 million is being requested for the FY 90. We support that request, and the appropriation of the remainder of the funds under the "cap" in future years.

The second element is not so obvious, but just as necessary. That is, it is essential to conduct an experiment program during the relatively short lifetime of the satellite. From such a program we will learn how these technologies can be applied. It will give communications systems designers and users experience with these new capabilities -- it will provide essential information on the propagation conditions and transmission characteristics of this new band. Such a program, which requires a modest budget augmentation, could also be used for service demonstrations and verification.

We know that NASA is working with industry to get their active participation and investment, but this effort has been hampered by the budget uncertainties mentioned previously. However, even a vigorous industry/experimenter program still leaves essential university research unfunded. Specifically, the augmentation would be used by NASA and universities for ACTS-related research in the communication sciences, for grants to universities for propagation equipment and experiments with the ACTS satellite, and for the building of six ground stations (and a flatbed trailer to transport them) for test and operation at different locations.

The ACTS program staff estimates that a total of about $19.5 million would provide equipment for an essential experimental program, and funds to operate the program and analyze the data from it, over a five-year period. Of the total amount, only $4.5 million is proposed for inclusion in the FY 90 budget. We support augmenting the ACTS program by the total of $19.5 million, and adding $4.5 million to the FY 90 NASA budget.

NASA Satellite Communications Program After ACTS

The funding of satellite communications programs in the United States, Europe and Japan can be seen in Figure 4. Note that European and Japanese funding increased as our NASA programs decreased. The increase in NASA programs between 1984 and 1990 is due almost entirely to the ACTS program. After the ACTS program, and without continuing U.S. sponsorship of satellite communications programs, our support of this field will be about one-tenth that of either Japan or Europe!

The United States should have three goals in the field of commercial satellite communications: capability, continuity and competitiveness.

We must retain and increase our technological capabilities in the communication satellite sciences and their application to commercial systems.

We must maintain continuity in the government, university and industry organizations that work on communications programs.

We must regain our competitive position if we are to provide the components and systems for our domestic needs, let alone compete in world markets.

An important element in accomplishing these objectives is the development of a NASA satellite communications program to be carried out in cooperation with other government agencies and with industry. We urge that Congress direct NASA to develop such a program and present it promptly to the Congress for its review and approval. Once a "technology roadmap" has been adopted, NASA and the other participants -- public and private -- can plan their contributions with some assurance that their efforts will fit into a coherent, continuing program.

THEODORE R. SIMPSON

Mr. Simpson has broad experience with the U.S. space program, the aerospace industry, and the federal decision-making process.

From 1961 through 1980, he worked on the design and development of a number of major aerospace systems, including reconnaissance satellites, the SR-71 aircraft, and the air traffic control system.

During 1981, as a Congressional Fellow serving on the staff of the Senate Subcommittee on Science, Technology and Space, he was responsible for the NASA budget.

From 1982 to 1985, Mr. Simpson was a Project Leader at ANSER. He did long-range planning on the military space program for Air Force Headquarters and the Joint Chiefs of Staff. This included working on the Air Force Space Plan, and the establishment of the U.S. Space Command.

In 1985, Mr. Simpson edited the IEEE Press book, The Space Station: An Idea Whose Time Has Come. The book discussed the factors involved in the presidential decision to build the NASA space station and how the station would be used.

During 1985-86, he was Director of Planning for the National Commission on Space, a presidential commission that recommended long-term goals for the civilian space program to the White House and Congress. He helped write and edit the Commission's report, Pioneering the Space Frontier.

In 1986-87, Mr. Simpson was Manager of Adavanced Programs for the General Research Corporation. He helped prepare the NASA response to the report of the National Commission on Space, and was involved with preliminary planning for the space transfer vehicle (STV).

Mr. Simpson is currently an assistant to the President of Grumman's Space Station Division. He is the Executive Director of a high-level Grumman technical advisory panel, and he recently helped write and edit the NASA report, Space Station Freedom Technical Overview.

He received a Bachelor's degree in Electrical Engineering from Manhattan College in 1961, and two Master's degrees from the Polytechnic Institute of Brooklyn -- one in Electrical Engineering in 1966, and the other in System Science in 1969.

RICHARD G. GOULD

Mr. Gould has had over 40 years professional engineering experience, the last 25 years of which have been in the field of communications satellites.

After several years working on the design of advanced missile, radar, and communications systems for aerospace companies in California, he began his work on the design and analysis of communications satellite systems at the Stanford Research Institute. He continued in this field at the Communications Sattellite Corporation and at the Office of Telecommunications Policy in the Executive Office of the President. Subsequently, he joined the FCC where he was responsible for the technical and economic aspects of the domestic satellite policy inquiry. That proceeding resulted in the "Open Skies" policy permitting competitive access to the U.S. domestic satellite market.

Since 1976, Mr. Gould has been President of Telecommunications Systems, a Washington-based firm of consulting electrical engineers with a broad range of government and industry clients.

One of Mr. Gould's specialties is the international regulation of satellite communications. He has been a participant in CCIR meetings since 1966 and has been a member of many U.S. delegations to ITU Administrative Radio conferences and to the regular and extraordinary meetings of the CCIR since that date. (This continuing participation in international satellite activities, and his association with foreign space scientists and engineers, has kept him aware of the existence of, and progress being made in, communications satellite programs underway in other countries.)

He is a Fellow of IEEE and is a member of its Committee on Communications and Information Policy, having served for some time as its Vice Chairman. He has edited books for the IEEE Press and has been Guest Editor of special issues of IEEE Society Transactions of satellite subjects. Mr. Gould received a Bachelor's degree in Electrical Engineering from New York University in 1949 and an MSEE from USC in 1954. For some years he was an instructor in extension graduate engineering courses for the University of California, Berkeley.

ENTITY POSITION STATEMENT

THE UNITED STATES CIVILIAN SPACE PROGRAM

The Institute of Electrical and Electronics Engineers, Inc.
1111 19th STREET, N.W. WASHINGTON, DC 20036-3690
(202) 785-0017

SUMMARY

In its almost thirty year history, the United States Civilian Space Program has placed requirements upon our technology which have resulted in major advances in computers, communications, guidance and control, and remote sensing. In more recent years, other nations have been excelling in technological endeavors which challenge the United States standing in space science and technology. The IEEE United States Activities Board urges the declaration of a set of national goals for our space program which will ensure regaining United States leadership in space, a primary goal of the Space Act of 1958. This Position Statement presents such a set of national goals which, with appropriate budgetary support, should ensure United States leadership in space.

United States Activities Board	02/18/87
Approving Entity	Date

In its almost thirty year history, the United States civilian space program has led to a significant improvement in our understanding of our planet, the solar system, and the universe beyond. It has provided the means for global communications, remote sensing, and information processing networks. In doing so, its mission needs have created requirements in electronics reliability, miniaturization, weight, cost and versatility surpassing all previous performance standards. Accordingly, the United States space program has been, and continues to be, a critical driver of science and technology.

To meet the space program's needs, major advances have been made in numerous fields of electrotechnology, including computers, communications, guidance and control, and remote sensing. These technological advances have become the foundation for major new high-technology industries which contribute substantially to our nation's economy and balance of trade, and provide a major source of employment for our nation's workforce.

In recent years, the United States has been faced with intense economic competition from abroad. Increasingly, other nations are excelling in technological endeavors which challenge the traditional leadership role of the United States. Space science, exploration and commercialization are not exceptions. The IEEE is concerned that the United States' standing in space science and technology is declining. To reverse this trend, we must recapture the vision and leadership that will enable the commitment of national resources that was exemplified by the Apollo program.

In 1961 President Kennedy announced a definitive objective for the United States space program; the manned landing on and safe return from the moon before the end of the decade. At the time, it was not evident that this objective was possible, nor that any single nation possessed the necessary resources for its fulfillment. With the proper vision, leadership and continuity of national commitment through three consecutive Administrations, the Apollo Program accomplished President Kennedy's objective on July 20, 1969.

The United States is now again on the threshold of a significant new space venture, the space station, which will provide a permanent manned presence in space for research and applications. Establishing a permanent presence in space is an essential step toward reinvigorating the United States civilian space program. However, given the severe budget deficit facing the Federal Government, the rationale and consequences behind funding an expensive enterprise such as a space station must be fully understood. We must establish definitive objectives for a balanced United States civilian space program, within which a space station would be one element. We then must provide the continuity of national commitment that will be required if we are to fully exploit such an effort for our competitive advantage.

A new national consensus on United States goals in space is necessary. While the National Space Strategy, as approved by President Reagan on August 15, 1984, set forth many of the necessary elements of such a statement of goals, stronger leadership by the Administration and the Congress is required to build the type of national commitment that will make these elements a reality. The declaration of a set of national goals for our space program is needed to provide a clear basis for a national consensus in the years to come. The IEEE United States Activities Board recommends the following declaration:

"Because of the technological and economic advantages to be derived by the nation that maintains leadership in space science, exploration and commercialization, the United States commits itself to maintaining preeminence in these fields. This will require a balanced civilian space program. In addition to replacing the shuttle orbiter and keeping the space station on schedule, the United States must allocate sufficient resources to re-establish a robust civilian space program that achieves the following goals within the next decade:

1. Expands the use of advanced applications satellites for public and commercial purposes to improve worldwide communications, navigation and remote sensing;
2. Expands the number of scientific space missions to extend our knowledge of our planet, our solar system, and the universe beyond;
3. Develops a mix of launch vehicles, expendable as well as reusable, which ensures greater access to orbit and which provides a broader range of payload capabilities;
4. Encourages the public and commercial use and operation of space systems and facilities;
5. Continues our exploration of the solar system;
6. Supports in-space research facilities for our universities;
7. Sponsors the early development of advanced technology required for long-range goals. The highest-priority long-range goals are to reduce sharply the costs of building and using space systems, and to establish human settlements on the moon and Mars."

NASA's future budgets must remain substantially higher than the FY 1986 level to provide the steady commitment necessary to achieve these goals. However, support for them will involve more than simply increased Federal funding. The barriers to private sector investments in space commercialization must be removed, and opportunities for international cooperation must be provided in those endeavors that are appropriate. The possibility of one day making space accessible to the general public must also be considered.

In summary, the IEEE United States Activities Board believes that with appropriate budgetary support, the balanced space program outlined above will yield important benefits to the nation through:

1. New public and commercial services;
2. Increased scientific knowledge;
3. Advancement of the national technology base.

This balanced program will also ensure regaining United States leadership in space, a primary goal of the Space Act of 1958.

ENTITY POSITION STATEMENT

NASA's Role in R&D for Satellite Communications

The Institute of Electrical and Electronics Engineers, Inc.

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Satellite communications has grown from its inception 25 years ago to an important U.S. industry generating several billion dollars annually. The growth of this new industry resulted from what history has shown to be a wise government-industry satellite communications technology development policy. Research, development and demonstration programs were primarily sponsored by NASA during the first decade of the space age.

The IEEE/USAB is concerned that the substantial financial, social and political benefits which have been derived from the creation of a satellite communications industry may wither and be lost, because of sharply curtailed NASA communications technology development programs.

The IEEE/USAB is further concerned that NASA has failed to foster a strong government commitment in communications satellite development programs, especially the Advanced Communications Technology Satellite (ACTS) project. The loss of NASA communications satellite development programs will cause irreparable harm to the industry. The satellite communications business is now facing intense competition from several foreign government-industry space organizations, as well as the competition of optical fibers as an alternative transmission means.

The IEEE/USAB recommends that the U.S. Governemnt:

a. Continue support of the Advanced Communications Technology Satellite Program by firmly committing the funds needed to complete construction and launch of the ACTS satellite.

b. Charge NASA with the mission to seek, encourage and implement telecommunications experiments jointly, with U.S. industry, to employ ACTS technology in demonstrations of new and innovative services.

c. Continue further communications technology developments, through NASA which exploit the unique properties of earth orbiting communications satellites, i. e. direct access from and to large areas of the earth, with wide bandwidths of frequency and with a variety of signals and services which can serve a large number of fixed, mobile and broadcast users. These developments are expected to improve the competitiveness of the U.S. space telecommunications industry, provide the public with lower cost telecommunications and help conserve electromagnetic spectrum.

United States Activities Board
Approving Entity

November 16, 1988
Date

1. In the 30 years since the launch of the Sputnik by the USSR the general public of the United States, through an agency of the Federal Government -- the National Aeronautics and Space Administration, NASA -- has spent nearly a quarter of a trillion dollars (1988) in the civil space area. This year Congress has appropriated over 10 billion dollars in continued support of Government civil space activities.

2. The United States has received many important tangible and intangible returns from this great investment.

3. Of those returns that have been of direct economic value to the U.S., that provided by the satellite communications business has been, by far, the largest.

4. In 1957 there was no satellite communications business, and long distance communications, especially intercontinental communications, was seriously limited in capacity, quality, and reliability and was very costly.

5. Through the conduct of imaginative, consistent, and substantial Government satellite communications technology development and demonstration programs, primarily by NASA during the first decade of the space age, and increasingly by U. S. business interests as well thereafter, the basis was laid for an industry, that today generates revenues of several billions of dollars per year. Directly and indirectly, satellite communications exerts an enormous influence on the social, political, and economic life of the U.S. and much of the rest of the world.

6. The U.S. was outgoing in its general cooperations with other countries that wished to become competent in the acquisition of space technology and in its scientific and commercial use. And it led in the related creation of international institutional arrangements that allowed the growth of communications via satellite throughout much of the world. Many of these other countries, who learned rapidly and well, now mount substantial space technology programs, and are now able to compete with the U.S. for increasing portions of the satellite communications business. Today, given the size and importance of this business, any significant enlargement of such successful foreign competition would jeopardize important U.S. economic interest, including employment, tax base, and international trade.

7. During the past decade important strides have been made in optical fiber technology. This alternative method of transmitting large amounts of data over long distances highlights the growing competition from foreign government-industry organizations with U.S. satellite communications and aerospace businesses.

8. Fortunately, the clear prospect of technological advances seen by our satellite communications interests in the early 1980's offered the promise that U.S. satellite communications firms would be able to compete successfully in the

long distance communications arena, and would be able to offer additional, new communications services as well, if such advances could be realized at an early moment, and in acceptable forms at reasonable cost.

9. Considerable debate took place during this time about what character and magnitude of technology development and demonstration program was called for that would allow such advances to be achieved and then capitalized upon by our private sector, and about what the proper roles of our private sector and Federal government should be in the support and conduct of such a program. Eventually a sufficient consensus was reached, and the cooperative government-private sector Advanced Communications Technology Satellite (ACTS) Program was inaugurated a half-dozen years ago. It then was expected to require total Federal appropriations of some $400 million throughout the remainder of this decade. It would involve several U.S. firms prominent in the satellite communications business, NASA and the DOD in an unusual, and unusually promising cooperative public-private technology development venture.

10. In the interim, for various reasons it has been difficult to maintain this consensus. For instance: many continued to question why such large, successful and experienced companies as are in the U.S. satellite communications business continue to need large public financial support; the Congress has been at particular odds with the President over government support of the program on seemingly basic "ideological" grounds; U.S. satellite communications firms have not had much experience in cooperating with each other and with the Federal Government when they have related non-government economic interests that they perceive to be at stake; the interests of firms that concentrate on the development of satellite communications technology are not necessarily coincident with the interests of firms who use this technology to provide communications services; the Federal Government is not adept at making economically-based (in contrast to politically-based) judgements; the U.S. has not had to compete with other countries in areas involving advanced technology until recently, especially where foreign governments subsidize their business firms in manners different from the ways that our Government subsidizes our firms; other countries may be able to take advantage of the results obtained by our open ACTS technology development program; and, it remains to be seen whether the technology to be developed can and will be taken up promptly and widely by U.S. firms who offer communication services.

11. Nevertheless, for three reasons the ACTS Program consensus has held: (a) the twin threats of foreign and technological competition are real, large and pressing, and our satellite communications economic losses to such competition could be great; (b) as our Government and our satellite communications private sector now begins to learn (painfully) about how to compete with other, increasingly sophisticated and determined, countries in the civil space arena, the basic political ground rule of "something beats nothing every time" takes on a new force and the ACTS Program, although seen as somewhat less than perfect in the eyes of some is in motion; and (c) it is becoming increasingly evident that the technological base to be acquired in the ACTS Program will allow, and prompt, other related technological strides to be taken in the post-ACTS era that could have widespread and enormously beneficial economic influence throughout the communications business.

12. However, the ACTS Program has suffered two unexpected and serious problems. These are: withdrawal of support to the light wave experiment (ACTS Optical Payload) by the Department of Defense; and disagreement between the President and Congress which has, each year, placed the authorization of funds for the program in jeopardy and thus generated inefficiencies in executing the program.

13. The IEEE/USAB views both of these developments with grave concern, and it shares this concern with those in the U.S. Congress who are following the progress of the ACTS Program. The IEEE/USAB and the Congress have been long term, consistent supporters of the ACTS Program, and therefore are keenly disappointed with cutbacks in the program.

14. The IEEE/USAB urges the leadership of both NASA and its ACTS industrial contractors to take those management and programmatic steps required to ensure that the program is brought to a satisfactory and timely conclusion -- and this explicitly means to a satisfactory financial as well as a satisfactory technological conclusion. The IEEE/USAB is confident that government and industrial leaders can do so, and believes that our country's interests would clearly be well served by their doing so.

15. While much of the ACTS programmatic attention focuses upon the development and test-demonstration of a novel and sophisticated spacecraft, it is important that NASA truly appreciate, and emphasize, that it is a new communications capability that is being developed. NASA should see that the test-demonstration portion of the ACTS Program includes complete communications circuits, functioning under a variety of circumstances and involves an array of surface equipments operated in appropriate settings. NASA must make an earnest effort in conjunction with U.S. industry to prompt the development of a private-sector market for surface equipments, and to see these equipments employed by private sector interests to test their operational suitability, and the suitability, as well, of new communications services that they could be used to provide. This will call for some considerable public/private program imagination and the sharing of responsibility, experience and cost in novel ways. The professional and business effort involved therein should be of as high a caliber as that expected to be exhibited in the spacecraft area. It should be kept in mind that the prior ATS-F and CTS spacecraft each exhibited many years of useful in-orbit lifetime -- indeed, several times the useful lifetime originally planned -- so that the likelihood is high that long-term equipment and service R&D could be mounted with reasonable confidence that experiments will enjoy a time span to achieve useful goals.

16. As to the prospects of the government withdrawing in the post-ACTS era from active and imaginative cooperation with our private sector designed to enhance, even further, the country's broadest business interests in the satellite communications area: the IEEE/USAB would view that as most unfortunate.

17. The U.S. is confronted with a serious and persisting imbalance in international trade -- one of unusual and truly grave import that is taking the earnest attention of many of the business and political leaders of the free world, including the Administration and the Congress. One of the few bright

spots in our favor is that of the aerospace area. It is simply imperative that we continue to sell large amounts of satellite communications goods and services to the rest of the world. To do so, we must learn to compete, satisfactorily, with smart hard-driving foreign business-government interests under circumstances that our technologists, engineers, and businessmen have not had to face during the entire post-WWII era.

18. The American taxpayers have been quite generous to those within and without the Federal Government who have wished to pursue their interests in the civil space arena -- especially over the past 20 years when it has no longer been necessary to do so for national security reasons as it was during the Mercury-Gemini-Apollo decade. Not only have great sums of money been placed at the disposal of NASA and its university and space industry partners, but they were all allowed unusual freedom in deciding what to spend it on.

19. Today, however, it appears to be questionable whether or not NASA can expect to receive such unusually favorable treatment for the indefinite future. As the large, persisting and frustrating budget deficit begins to corrode support for Federal expenditures that are deferrable relative to those that can command clear and immediate support from large and politically influential taxpayer groups, the NASA budget almost certainly will be brought under sharp scrutiny, as it should.

20. Certainly, under such straightened national economic, and Federal Government financial circumstances, it should not be unexpected that large Federal programs that do not promise a direct visible return would be subject to reduction, stretch out or elimination. All of our taxpayers have the right to expect that the satellite communications area will receive particularly helpful attention by those Government employees whom these taxpayers are supporting, for it is the only private sector area that, through the substantial taxes that it pays, reduces the individual taxpayer's burden in supporting the nation's public space program.

21. It should not be inferred that the IEEE/USAB necessarily supports, in detail, all of the present government satellite communications technology development activities. Nor should it be inferred that the IEEE/USAB now claims to know how to deal with all of the complex and sensitive issues that faces our satellite communications business -- especially those issues that seemingly call for novel and close cooperation between free enterprise and Government. And it should not be inferred that the IEEE/USAB is not supportive of other Government civil space aspirations and activities as well. But the IEEE/USAB does mean to be understood to believe that the economic future of the United States is important and that the satellite communications business is a very important element of that economic future.

22. The IEEE/USAB also notes that Federal law, in the words of the Space Act (Public Law 98-361), declares, "... that NASA should seek and encourage, to the maximum extent possible, the fullest commercial use of space." (Underlining added here.) Any withdrawal by the Executive Branch from working closely with our commercial-industrial satellite communications business interests would be counter to the intent of this law.

23. In this context, the IEEE/USAB notes the expressed views of the President of the United States. The FACT SHEET covering the "Presidential Directive on National Space Policy" issued by the White House on February 11, 1988 expresses these views as follows: "The directive also states that communications advancements are critical to all United States space sectors. To ensure [that] necessary capabilities exist, the directive states that the United States Government will continue research and development efforts for future advanced space communications technologies. These technologies, when used for commercial purposes, will be without direct Federal subsidy." These words clearly offer the opportunity to see a long term cooperative effort be created by our business and government sectors -- a consistent, long-term effort that would replace the start-and-stop efforts of the past dozen and a half years.

24. Therefore, the IEEE/USAB recommends that the U.S. Government:

a. Continue support of the Advanced Communications Technology Satellite Program by firmly committing the funds needed to complete construction and launch of the ACTS satellite.

b. Charge NASA with the mission to seek, encourage and implement telecommunications experiments jointly, with U.S. industry, to employ ACTS technology in demonstration of new and innovative services.

c. Continue further communications technology developments, through NASA, which exploit the unique properties of earth orbiting communications satellites, i.e. direct access from and to large areas of the earth, with wide bandwidths of frequency and with a variety of signals and services which can serve a large number of fixed, mobile and broadcast users. These developments are expected to improve the competitiveness of the U.S. space telecommunications industry, provide the public with lower cost telecommunications and help conserve electromagnetic spectrum.

Mr. **Volkmer**. Thank you very much.

Mr. Gould?

Mr. **Gould**. Thank you, Mr. Simpson.

Good afternoon, Mr. Chairman, members of the subcommittee and committee staff. Thank you for the opportunity to comment on NASA's Advanced Communication Technology Satellite, the ACTS program, and its relation to the Fiscal Year 1990 NASA budget.

In the beginning, NASA created communications satellites and satellite communications. Thereafter, for many years, the United States led in the commercial exploitation of satellite communications. Today, it is a multibillion-dollar U.S. industry. So far, it is the best and perhaps the only example of a private commercial, profitable, new industry created from space technology.

The United States still leads, but our leadership has been dwindling. It is decreasing in the sales of large Earth stations, the manufacture of spacecraft, and in satellite launches. It is easy to pinpoint the turn of that tide, the date when the United States began to lose its preeminence in satellite communications. It was 1972, when the CTS Hermes program ended.

The CTS Hermes satellite, cosponsored by NASA, was a joint program with Canada. In that program, we developed high-power, high-frequency broadcasting satellites, leading the way to commercial exploitation of the 12- and 14-gigahertz bands for communications. Among other things, the United States developed and contributed a 200-watt traveling wave tube, the highest power tube built to date at those high frequencies. But that was the last COMSAT flight program of NASA and the United States, except for the ACTS program.

The next generation of still higher power tubes was built not in the United States but by Telefunken in the Federal Republic of Germany and by Thompson CSF in France. High-power broadcasting satellites that will be built in the coming years will use those foreign-made tubes.

There are still a few bright spots in space, far fewer than 1,000 points of light, but let me give you two examples. A U.S. company recently won the bid from Intelsat for the next generation of its satellites, of Intelsat's 7-series, but just barely. Ford won over a European consortium, the first time that Europe has bid by itself as a prime contractor rather than as subcontractors to a U.S. firm. Its bid was fully compliant, technologically sound, and came from a fully mature European space industry—Europe, the continent that brought you the Airbus, the Ariane launch vehicles, and the Evtelsat satellites.

Only the recent decline in the U.S. dollar vis-a-vis European currencies, and some concern of Intelsat over the divided project management presented by a multi-nation consortium, kept Ford in our commercial COMSAT space future.

Another example: We will soon have a mobile satellite system operated by a consortium of eight U.S. companies. But they are using technology pioneered by NASA through its long-time support of the MSAT project at the Jet Propulsion Laboratory. But there is not much more in the pipeline that can be turned to commercial advantage.

Now let me talk about the ACTS technology. ACTS is the next frontier for communications satellites. In that program, we will explore still higher frequencies in the 20- and 30-gigahertz band, wider bandwidths, multiple-beam antennas, scanning antennas, which will give effectively higher power on Earth to permit smaller and less expensive Earth stations to be used. We will use on-board processing of communications and on-board switching.

We have competition now in this new band and in these new technologies. We have it today from Japan, which has such a satellite in orbit; Italy, which will launch one this year; from the United Kingdom, Germany, and France as well.

Now let me talk about money. Almost every year since 1983 or 1984, the budget proposed by NASA includes the ACTS program when it is sent to the White House. But each year, a funny thing happens on the way to Capitol Hill: the ACTS program is missing from the NASA budget when it gets here. Each year Congress restores the line item for the ACTS program. The program is now about 73 percent complete and will be finished within the cap set by Congress.

The IEEE, its committees, and its members are grateful to the Congress for that support to permit these yearly advances into new technology that will make possible future commercial applications and future foreign sales.

This year we urge the Congress to do three things: authorize $61.4 million toward the completion of the ACTS spacecraft; two, authorize $4.5 million for an experimental program that will augment the existing planned program; and three, and perhaps most important, direct NASA to develop and propose to Congress for its approval a continuing, coherent communications satellite technology development program. Such a continuing program will prevent these yearly cliff-hangers, will maintain continuity in our communications satellite technology programs, and will keep us current and competitive.

Thank you.

Mr. Volkmer. Thank you very much, Mr. Gould.

Mr. Mattson?

STATEMENT OF LAWRENCE B. MATTSON, CHAIRMAN, TASK FORCE ON CIVILIAN SPACE POLICY, AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Mr. Mattson. Thank you, Mr. Chairman, members of the subcommittee, and staff.

I am pleased to have the opportunity to present the views of the ASME Task Force on Civil Space Policy on the fiscal year 1990 budget request of the National Aeronautics and Space Administration. Although there is a proposed budget increase for fiscal year 1990 intended primarily for the space station and shuttle programs, the task force is concerned that NASA's research and technology programs may not be funded at a sufficient level to continue our Nation's preeminent position in civil space activities.

We have focused our review of the budget request on a number of areas of the space program where we believe improvements are warranted and are primarily interested in pointing out the need for a consistent space policy. We believe proper planning in the long-range context and proper execution of these plans can turn around the erosion of our lead in space.

With regard to national space policy, the task force commends the legislative initiative of the 100th Congress to reestablish the National Space Council as a step in this direction. We hope the new administration will take this opportunity to give more visibility to civil space policy and to revitalize and coordinate the planning process begun with the National Space Policy announced in February of last year.

Although there is enormous pride throughout the Nation in the return of our space shuttle fleet to operational status, the job of providing a fleet of resilient, reusable vehicles to meet the space transportation needs of this country has not been finished. The proposed budget provides only $20 million in spares for the shuttle and offers no alternative to the problems experienced last year when critical parts were not available to support the schedule.

In recognition of this Nation's need to ensure that the space shuttle continues to offer the safest possible means of transportation for its crew, NASA is planning to initiate full-scale development of the advanced solid rocket motor and has also been studying a liquid rocket booster which has the potential for even greater crew safety. Before proceeding with the ASRM program, however, we believe it to be in the national interest to carefully assess which of these two systems would best serve this Nation on a long-term basis.

We are pleased to note the much-needed support provided to the space station program as reflected in the fiscal year 1990 NASA budget. Space Station Freedom will provide the node in space from which we can look back to Planet Earth to seek solutions to the many problems that currently plague our lands, oceans, and atmosphere. It will allow us to monitor our environment and service satellites dedicated to improving conditions on Earth.

In addition, it will also provide a platform from which we can develop the technologies needed for the future expansion of man's presence in space. The spinoffs associated with artificial intelligence, robotics, and other technologies will result in many applications to benefit every man, woman, and child in this country.

The space station will not only provide America with a permanent manned presence in low-Earth orbit but will be the logical steppingstone required to achieve all of our future goals in space as we move into the 21st century.

We support the need for trans-atmospheric research and technology related to the National Aerospace Plane because we believe this program to be vital to our Nation's competitiveness in aerospace in the 21st century. Technology developments in support of this kind of vehicle are key to future low-cost, reliable space transportation systems, and development of a flight test vehicle to demonstrate these technologies is essential.

The space science program planned in fiscal year 1990 will provide a well-balanced initiative to complement our manned flight programs. Calendar year 1990 will see the launching of Galileo, Ulysses, the Hubble Space Telescope, and the Gamma Ray Observatory. These spacecraft, along with the Advanced X-ray Astrophysics Facility, a new start in fiscal year 1989, will provide us with insight into the origins of the universe.

The Comet Rendezvous Asteroid Flyby-Cassini mission, a new start for fiscal year 1990, will provide excellent insight into the evolution of life and the solar system by examining asteroids and a comet believed to be the most primordial matter in the solar system. The task force strongly encourages the committee to increase funding for space research and technology programs to a level commensurate with the importance of this area.

Pathfinder, a program to develop a broad set of technologies for our next generation of missions, is being severely underfunded. This research and technology program is critical to our understanding of the risks inherent in space exploration and overcoming these risks.

We urge Congress and the administration to place increased emphasis on studying cost- and risk-reducing solutions to NASA's future endeavors to reach out into space.

The task force notes the increased emphasis being placed on commercialization and privatization of certain programs and facilities formerly budgeted by NASA. Although these programs could result in an estimated savings of several hundreds of millions of dollars to the government if financed by the private sector, the task force wishes to emphasize that the marketplace for commercial space programs is still in its infancy. Some of these programs will continue to be faced with risks which industry may be reluctant to assume.

We hope that the new thrust in the commercialization and/or privatization of space will include some method where the private sector is protected from the risks of pursuing a federally encouraged effort only to have support drop short of the mark. Space is still a risky marketplace in which to do business, and it will require some form of government assistance until these businesses are somewhat self-supporting.

With regard to technical manpower and engineering in this country, we are greatly concerned that with the diminishing number of U.S. students studying engineering, there may be a future shortage of key technical personnel. Currently over 50 percent of the U.S. engineering doctoral students are foreign born. Unless more U.S. students are attracted to science and engineering, this country will soon begin experiencing extreme difficulty supplying the necessary top engineering talent to staff technical organizations like NASA.

Mr. NELSON (assuming Chair). How do you recommend that we change that?

Mr. MATTSON. I have some suggestions here. Let me refer, Mr. Chairman, to my submitted statement earlier.

We endorse the establishment of the National Space Grant College and Fellowship Program, which seeks to broaden the base of universities involved in aerospace science and offers fellowships to trained professionals in the aerospace science.

We also recommend that the amount of the stipend and number of engineering recipients in NASA's Graduate Student Researchers Program be increased. The stipend in this program has been fixed for a number of years.

Secondly, we recommend that the number of NASA Summer Faculty Fellowships in engineering be increased. This program has been very successful in familiarizing engineering educators with advanced space technology.

Mr. NELSON. Earlier you talked about Pathfinder. Are you satisfied with the level in this request from the Administration for Pathfinder?

Mr. MATTSON. Mr. Chairman, no. I believe, in fiscal year 1989, when this program got started, it was planned to be funded at a level of $100 million. That was reduced to about $40 million. This year, in fiscal year 1990, the budget request contains $47 million for this area. I believe it is grossly underfunded.

Mr. NELSON. I agree with you. If we took it up, do you want to recommend any place we ought to cut out about $53 million elsewhere in the budget?

Mr. MATTSON. No, I cannot propose any cuts in the budget. The NASA budget is about 1 percent of the Federal budget, and the technology spinoffs that we have seen over the last 30 years out of NASA's programs, I think—it is a hard thing to get your hands around, but it is significant in every way in improving the lifestyle for every American. I cannot propose to reduce any of the NASA budget.

Mr. NELSON. This committee basically agrees with you, and therein lies a very difficult task.

What do you think about ACTS?

Mr. MATTSON. The Advanced Communication Technology program, I personally fully support. Our committee or task force did not address that issue in this prepared statement. But I look at the ACTS program as a follow-on to what was formerly known as the Advanced Technology Satellite, which provided the basic technology for this country in the commercial communications satellite area.

Mr. NELSON. What do you think about Mr. Gould's recommendation that there be $4.5 million for ground experiment stations for universities for ACTS?

Mr. MATTSON. I cannot comment on that. I am not qualified, I do not think.

Mr. NELSON. Mr. Gould, amplify on that for us.

Mr. GOULD. Thank you, sir.

Developing the technology is one thing. Putting it to application, convincing potential users of its utility, and getting experience in using the technology are equally important.

One comment about the funding for the ACTS program. The program is now 77 percent complete. The remaining 23 percent is some $112 million over the next several years, of which only $61.5 million are needed for this year's completion. We are almost there. We have got the satellite and the program almost finished. That plus the augmentation to permit the experimentation both by the NASA scientific community and universities for research using the satellite and learning its commercial applications will be money well spent.

The most recent application of that technology is something that had not been intended, I think, when the program was originated; that is high-definition television, which is now thought by the Congress and others as an extremely important technology to explore. The ACTS satellite will have both the bandwidth and a new frequency band to demonstrate, use, learn more about that region for application in the satellite transmission of high-definition television.

Thank you, sir.

Mr. NELSON. Dr. Reiff, what do you think about this $4.5 million for the universities?

Dr. REIFF. Well, we all have dusty telescopes in our closets that we do not use properly, and I think one problem with NASA in general, and a hard lesson we learned from the shuttle program, was that if you did not have the science to back up the technology, you are wasting your money.

We only invest roughly 20 percent of NASA's money into the science. If we are going to do ACTS—and this is something you have to decide, and it is a hard decision—then you have got to use it properly, and I think an investment of $4.5 million to put ground stations in universities might be a very appropriate way to bring that sort of technology to the universities where it could be used both for science and for education.

Whether you do the whole program, of course, is another sticky issue. We have got lots of wonderful things that we can each name, each of which can bring another $100 million to the already too-big NASA budget. I could name three or four myself. So that is a sticky issue, whether you do it at all. But if you do it, let's do it right and let's get everyone involved.

Mr. NELSON. Our problem here is that we have about $14 billion worth of requests squeezed into a $13.2 billion budget, and we are trying to make it all fit, and it does not necessarily fit.

You look like you are about to ask something, Mr. Perkins.

Mr. PERKINS. Mr. Chairman, I share your concern. I was interested in Mr. Mattson's earlier comment, and I think it was that he did not think the NASA budget should be cut at all. Well, we agree with that, as the chairman said, and this committee is not one that is involved in a situation of wanting to cut anything. We are very much the foremost advocates you will find for the space program, probably, on this side of the Hill.

The problem gets to be, given the fact that we have others who are not quite so understanding in terms of the overall budget process, what within the prioritization that we have to eventually make do you feel, as a panel, are the priorities that should be emphasized. That, I suppose, is ultimately the question. If worst comes to worst, what goes?

I think that probably, Mr. Chairman, would be my initial question to the panel, and I would be very interested to hear that sort of prioritization.

Dr. REIFF. You are looking at me. I hate to be the one who picks and chooses because it is——

Mr. PERKINS. Well, so do we.

Dr. REIFF [continuing]. Yes, I know. I hear you. Within the Office of Space Science and Applications, which, of course, is my bailiwick, it has been very carefully crafted out, and I think a lot of hard choices have already been made, and they have done a lot of squeezing to get a new start for CRAF-Cassini, which has been pointed out by a couple of speakers as being very exciting, and it has a tremendous deadline. The comet is coming. We are either going to go see it or it is going to pass us by.

But some things do not have hard deadlines, and those are the ones that, if we start looking with jaundiced eyes, those are the ones that probably should be looked at first.

Mr. **Perkins**. Are you talking about Pathfinder?

Dr. **Reiff**. Not necessarily Pathfinder. I am thinking—and I hate to sit here and say it—I am thinking that perhaps bigger programs that cost more money that you can think of that do not have hard deadlines might be postponed.

Mr. **Perkins**. Give me some examples. [Laughter.]

Dr. **Reiff**. The things that are coming on line the biggest, of course, are the ones that are the——

Mr. **Perkins**. Space station?

Dr. **Reiff** [continuing]. That is an interesting thing to consider. Now, I think space stations are terrific. They really pique the interest of the people. I am on several CB-level space bulletin boards, and there is a lot of talk among the children that are on this bulletin board of how we need a space station and how the Russians are really showing us up with their MIR space station, and they have been up there for years and years.

And yet, when you really get down to it, it is an expensive thing, and it is something which we should be working on for certain, but maybe we can stretch it a little bit if times are very tight. I think we have to make some very hard choices, and that may be one of the ones that is least problematical to stretch out, whereas some of these research programs that we are working on just cannot be stretched. The comet is coming. We missed the opportunity with Halley. If we are really going to go into cometary research, the time to do it is today.

Some of our foreign science programs that we are doing together with the Russian mission, the global geospace mission, which involved Japanese and Russian and European participation, this is something that has gone on-line, it is international in scope; we have got commitments and so we have to do it.

It is a tough choice. I would hate to do that choice. But I think that is an obvious place that a stretchout would not be fatal.

Mr. **Nelson**. Dr. Grey had a comment for you.

Mr. **Perkins**. Sure.

Dr. **Grey**. Mr. Perkins, with all due respect, I think you have asked us the wrong question. There is no doubt that there are going to be cuts and slices made in the budget, but I think the purpose of this panel, or at least the viewpoint of this panel, is that we are here before the authorization committee for the space science and application program, and the best thing we can do is find reasons why we can find 1 percent of the overall Federal budget to devote to the NASA program.

We end up, if we look at cuts and slices with stupidities—and I use the word advisedly—like terminating the LandSat program for the sake of a $10 million appropriation for the rest of the year; if we keep that attitude, we will end up slicing and cutting and chewing away at things which our future absolutely depends upon.

I think, yes, we are going to suffer cuts somewhere along the process. We all recognize that it is going to happen. But I think, if we begin at this point to start slicing the budget early in this phase, in this committee, I frankly feel that is the wrong approach.

Mr. **Perkins**. Doctor, you misunderstand. We are not attempting to slice the budget at this stage. The problems get to be, at some stage there is a prioritization that must occur, and when that does occur, the question then gets to be whose neck do you put on the chopping block. And, ultimately, that is something that, while it is not to be decided now—and I want all the wonderful testimony that I can get about the importance of increasing the NASA budget, and we will push that position—but, ultimately, we deal in a system of compromise, and when it comes to that, just for our own viewpoint, we are interested in hearing what the other rankings and priorities are within individual communities.

Dr. **Grey**. Mr. Perkins, the only problem with doing that is, once you say it up front, then it is gone forever, and you do not get the chance to negotiate it again. I think I would like to see that negotiated when we absolutely have to negotiate it, not before.

Mr. **Perkins**. All right, doctor, now let me just add one thing. If that is the attitude that is taken, then you must realize that this committee, when the decision ultimately has to be taken, is then going to have to deal in a relationship of making its own best guess.

So that is the point here. You are not talking to people that are not for the space program, that are for as big a budget as you are going to get. It is a question that you are talking with people who have to deal with the realities of, once you have what you are going to get, how do you fit it in. And that, ultimately, is something we like a little advice on every now and then.

Just talking, if the chairman will indulge me, about some other programs I have some interest in, we were talking about the Japanese program, doctor. There has been some question on the Space Telescope, the delay that we have had in putting it up into space. I guess the Russians presently have a radiotelescope project that is fairly large in scope that is going to give them an amazing capability, and the Japanese are looking at one presently, perhaps with some sort of U.S. involvement in the future.

What are your feelings in terms of some of the radiotelescope projects that are going on presently?

Dr. **Reiff**. Well, of course, radiotelescope is a completely different technology.

Mr. **Perkins**. Oh, sure.

Dr. **Reiff**. You can do radiotelescopes from the ground.

Mr. **Perkins**. Not a big enough base, though.

Dr. **Reiff**. Well, you can also do interferometry using lunar bases and using distant spacecraft.

Mr. **Perkins**. That is what they are doing. That is what the Russians are doing.

Dr. **Reiff**. You can actually do interferometry, yes, and that is really a very exciting technology. And when you do distant spacecraft interferometry, it is very important that you have very precise positioning and very precise phase——

Mr. Perkins. Of course, it only lasts for a very short period of time, the availability of using such an instrument. But certainly, doesn't that give us a capability far in excess of anything that we see on the horizon now?

Dr. Reiff [continuing]. Well, of course, you are looking with radio eyes, then.

Mr. Perkins. Sure.

Dr. Reiff. You see the radio universe, which is galaxies and magnetic fields and trapped particles, and that is a different universe than the optical universe.

Mr. Perkins. Sure.

Dr. Reiff. And they are all exciting. The things we have learned with infrared eyes have really opened our eyes to the formation of planets among other stars. The things we see with ultraviolet tell us about the energetic particles of the aurora.

So, yes, we need to look in all wavelengths and with whatever capabilities we can, and holding hands as much as possible with our international partners. I think the more we share technology with them, the more we share missions with them, the more science we get for the dollars.

Mr. Perkins. I suppose, doctor, my question really gets to be, do you think the study of pulsars is really where most of the scientific orientation should be in the immediate future? I suppose that kind of relates directly to what type of telescope we are talking about.

Dr. Reiff. Well, I mean, we are going to see a pulsar, probably, from Supernova 1987–A in the next year or two, and that is going to make a lot of my colleagues at Rice University very happy.

Mr. Perkins. Yes, it certainly should.

Dr. Reiff. There have been a lot of theories on pulsars coming from supernovas.

But, I mean, there are all kinds of science, and all kinds of science are exciting, and all kinds of science have value. The nice thing about small university science is that you can do it all, if you have a grant with a faculty member that is $30,000 and he has two graduate students or one research associate—you can pass out a lot of 30Ks around the country and get a lot done, and sometimes you get surprises, like this possible fusion in a fuel cell.

Mr. Perkins. Right.

Dr. Reiff. Big science, on the other hand, is very expensive, and is something that we have to weigh on a national level, what big science we are going to do. And yet a lot of the big science does benefit the individual researchers.

We have a fellow at Rice who goes and spends a week looking through the IUE system at Goddard. So it is a small grant, a small person, yet it is a big facility. So as long as we recognize that our big sciences are facilities that small people get to use, then I think everybody benefits. But we do have to make the hard choices of which of the big ones we can do, because we cannot afford them all.

Mr. Perkins. Yes. Well, there has been an ongoing argument about big science versus little science in this committee for years, and of course, how do you prioritize within that concept? So certainly I am not trying to pin you down. There are a lot of new areas here that strike me as exciting that I am wondering, particularly, with pulsar research in the immediate future, if it is not something we should be looking at little bit closer at. Like you say, there are some things that can be put off and some things that cannot.

Dr. **Reiff**. Well, for example, Jupiter acts in many ways like a pulsar, and the new Galileo mission will be studying it in situ for the first real time.

Mr. **Perkins**. Well, my personal feeling is, again, I was disappointed when we had the slippage of the Mars Observer before. I hope that never occurs, or is allowed to occur, again. I support wholeheartedly the Pathfinder initiative to a great degree. I just wonder sometimes—there has been such a lag time, in all honesty, because of the shuttle situation—if some of the things that we are talking about putting up any more are not just getting a little bit dated. That is something that no one likes to look at very much, but I think, if you are going to look at it from the best dollars spent, that is something we need to look at.

With that, I thank the chairman for his indulgence.

Mr. **Nelson**. You know, if we had had our way and could have gotten NASA to stay on schedule with the Mars Observer in 1990, now with this unfortunate mishap on the two Soviet Phobos, wouldn't it be exciting that here we would be within the span of less than a year? We would be having our own Mars mission. It was unfortunate that this has happened to the Soviets. Maybe it is another opportunity for the renewed, Dr. Reiff, holding hands that you are talking about. Maybe this will generate more Soviet participation and a greater invitation by NASA in extending the invitation on participation on this Mars Observer mission.

Mrs. Morella?

Mrs. **Morella**. Thank you.

I direct this question to anybody on the panel who would like to respond to it, and it may tie in with what Mr. Perkins just asked regarding cuts.

The recently released Aeronautics Safety Advisory Panel report has questioned the relative merit of the advanced solid rocket motor program. I wondered if you would like to comment on whether you support this program. Do you think that the dollars that are going into that program could well be spent in other areas?

Mr. **Mattson**. I would like to respond to that, Mrs. Morella.

Mrs. **Morella**. Great, thanks, Mr. Mattson.

Mr. **Mattson**. I think we are on the wrong path with the ASRM. This is my own personal view now; it is my own personal opinion.

There is another way to approach the problem of enhancing the safety of the shuttle. NASA has been studying this since the fall of 1987, and all indications are that a liquid rocket booster will give the orbiter infinite abort capability. With the SRM presently being used, there is no abort capability until separation of the solid rocket boosters during the first couple of minutes of flight.

With the LRB, which has engine-out capability, you can run up the boosters on the stand before release to make sure everything is operating correctly. You cannot do that with an SRB. It has engine-out capability to return to the launch site or in Africa, and it gives you the added lift capability of 20,000 pounds within about the same dollars that they are talking of in developing the ASRM.

My own personal opinion is that we ought to be looking harder at the LRB.

Mrs. **Morella**. Dr. Grey?

Dr. **Grey**. I would like to add something to what Dr. Mattson has said. The AIAA, of course, has not had an opportunity to take a formal position on this, but in our statement we have indicated that a choice needs to be made among the various alternatives to upgrade the booster on the shuttle.

Now, one scenario that one might look at, the Safety Board has indicated that upgrading the present redesigned solid rocket booster would, in essence, accomplish the goals of the advanced solid rocket motor for considerably less investment, about $1.5 billion less, over a period of several years.

And then Dr. Mattson's suggestion that we look at the liquid rocket booster fits into place very nicely, because at that point, if we look at the requirements of the main investment cost of the liquid rocket booster, it is in the new engine that would need to be developed for such a booster. That engine has remarkable congruence with the engine required by the Air Force's advanced launch system, and in fact, if a common engine development were pursued, most of the investment required for the liquid rocket booster would be borne by the ALS program.

I might add that the Air Force office responsible for ALS supports the concept of a common engine development for these two boosters.

If we then look at the prospect for, let us say, applying some of the money that might have been spent on the advanced solid rocket motor and applying it toward the liquid rocket booster, with the additional funds that would be supplied by the ALS program, it appears as if, although perhaps a few years later than the advanced solid rocket motor, we would have all of the benefits that would accrue that Dr. Mattson has pointed out of the liquid rocket booster, without a great deal of additional input in terms of the budget.

Now, with regard to operational costs, I think these really need to be looked at. There is some question as to whether the liquid rocket booster or the solid rocket booster would involve differences in operational costs. I do not think we know the answers to that yet, but it is an important long-term question that needs to be explored.

Now, again, we have not taken any position that this should be done, but it is certainly an area that does need exploration and investigation, and it should be done fairly soon.

Mrs. **Morella**. Would anyone else like to comment on it, or does that mean you do agree with the two statements?

Dr. **Reiff**. Well, I am certainly not the technical expert that my colleagues on the panel are, but I would like to just note that the new Russian shuttle, which superficially seems to match ours in virtually every way, the one major difference is that it has all-liquid rocket technology.

Mrs. **Morella**. I had another question. Recently there was an article in Science magazine which suggested that the value of the space telescope has been undermined by the long cycle of development and archaic computer hardware and the software in the program.

Would you agree with that? Would you, therefore, if you do agree with that, say there is something wrong with the length of time that it seems to take us for these kinds of programs, large-scale programs?

And also, there was a GAO report which I learned about—I have not read the report—that claimed that, tying into that, computer technology which is used on NASA's spacecraft is 10 to 20 years old at the time of launch. So again, is this a problem? What do we do to correct it?

Mr. **Simpson**. It is a problem.

Mrs. **Morella**. Anybody. Mr. Simpson?

Mr. **Simpson**. These are long programs. The space telescope was probably conceived of in the early seventies, and at that time, when you started bidding on the program, you were bidding on what you thought could be done in a reasonable amount of time. It was supposed to have been launched in 1986. I suspect that that was another factor in why it is now viewed as being old, but I think it is still going to give good science, and I suspect that Robert Frosch was correct when he said that there will probably be some Nobel Prizes awarded to the information gathered from it.

Mrs. **Morella**. Dr. Grey?

Mr. **Grey**. I agree with Mr. Simpson. These programs do take a long time. One of the points we have made is that stretchouts in a program, for whatever reason, are always costly, either in terms of money or in terms of performance, and getting things done as soon as possible, again with the requirement sometimes of spending more money up front, unfortunately, which is difficult in tight budget years, will very often either save costs in the long run or get performance into orbit sooner.

Now, with regard to shuttle avionics, one of the current programs that NASA is pursuing is to upgrade all of the avionics and all of the computer systems in the shuttle, and it is proper. Those systems were designed back in 1972. They are 18 or 20 years old, and they do need upgrading.

But again, in a reusable vehicle like the shuttle, it is possible to do that. As long as, again, the budgetary support is there, we can certainly upgrade them. The limitations are very often budgetary, and in some cases scientific development takes longer than you expect sometimes; that is why we do development.

Mrs. **Morella**. Is it also decisionmaking that is kind of derelict——

Mr. **Grey**. I think most of the decisionmaking is budget-driven. In some cases it is not, but I think in most of these cases, where we find we have older systems on board, it is simply because there have been budget stretchouts, and the decision has been made, well, we will put it off a year; we will save a little money this year.

Mrs. **Morella**. So you are not that fearful that there are adverse ramifications other than, of course, that it drags things out?

Mr. **Grey**. I think the space telescope is a wonderful machine, and I think we are going to learn a great deal from it. It would be nice if it were newer, but it is fine the way it is.

Mrs. **Morella**. Mr. Gould?

Mr. **Gould**. Mrs. Morella, just a parallel in another field to emphasize or make the point that these delays run through all fields, and no one apparently has found a way. In the military procurement field, I understand that the average length of time from a weapon system being proposed and the first procurement contract—and, by the way, it has gone through an awful lot of hurdles before it gets to the proposal stage, and it takes a long time after the procurement contract is let—but just between those two times is 11 years.

Now, there, there is some even greater incentive to get the device operating because of the fear of military competition, and the number is still that high, the period is that long.

Mrs. **Morella**. And they still don't operate right in many instances.

Dr. **Reiff**. I don't want you to get the impression that the space telescope has just been sitting in mothballs letting its RTGs decay for the last few years. [Laughter.]

The RTG is a problem.* But in many cases, the principal investigators on the instruments have been working, upgrading, updating as much as possible, even almost as we speak, the computer systems, the hardware systems, and everything. I know missions that are on-line, like GGS and CRAF, they go through an initial announcement of opportunity, you make a proposal for an instrument that, as the technology improves, you end up attempting to improve your instrument, within the constraints of the funding that you have, and I think often a certain amount of delay has turned out to be a better product because you have had a little more time to optimize things.

The important thing is that the instrument that we send in space be flexible and have enough computing power on board to handle emergencies. Voyager 2 that was launched 12 years ago has had to reprogram around a couple of really major problems and yet is operating wonderfully because they had enough smart computers that it could reprogram itself, and that was 20-year-old technology. So I think we are going to see that a lot of space still exists.

Mrs. **Morella**. That is very encouraging.

Thank you, Mr. Chairman. I thank the panel, too, for your expert testimony.

Mr. **Nelson**. You know, we have been trying to get multi-year funding for NASA. Do you think there is anything instructive, by virtue of the fact that the full-provision funding for the replacement orbiter has now caused what is unusual in government, an underrun instead of an overrun in its production costs, do any of you happen to attribute that to the fact that the funding was there up front? And what could you give us, from the value of your experience, that might suggest that we might be on the right track urging multi-year funding? Dr. Grey and Mr. Simpson?

Mr. **Grey**. Go ahead.

Mr. **Simpson**. I would just like to make a quick comment, and that is that the longer you stretch a program out, the more it costs.

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*See appendix 7, p. 1187.

If you keep things on schedule, you are going to save money, and you are going to avoid ambivalence like is on the current space station and on the ACTS program.

People who are kind of hanging out there and waiting, like the "Perils of Pauline," to find out whether the program is going to be cancelled or not are not as productive as people who have the money and know that they are moving forward. It is not a good atmosphere. You want to give them the amount of money they need to get the job done and keep on moving forward rather than cutting back or leaving them in a state where they don't know where they are from day to day.

Mr. **Grey**. I totally agree, not only on the stretchouts but also, when you look at an industrial management plan, when a corporate entity makes up its mind to invest in an area after having done research and development, the planning is done on the basis of the total life cycle expenditure for that development, and all of the activity is aimed at meeting that budget. That budget may be 1 year or 2 years or 10 years in some cases. Doing year-to-year budgeting and allowing things to progress on a year-to-year basis is anathema to good management.

Now, we do it in our government because that is the way we have always done it, and I think this committee's initiative in asking for multi-year procurements is one of the best things that could possibly happen to the space program, because then we can bring things in, maybe not under cost but certainly within a reasonable degree of projected cost and projected time.

Mr. **Nelson**. Mr. Gould?

Mr. **Gould**. I can add some more support for that idea. In particular, the ACTS program has been hampered by this yearly uncertainty in getting industry participation, for the reasons that Dr. Grey cited. Without knowing whether the program will continue, whether it will come to fruition, whether there will be a satellite to experiment with, is one big reason for the reluctance of industry to invest in equipment, to work with the system.

If they had some assurance, some confidence that the program would continue, we would see a lot more participation than we have. It is going to take that for private companies to justify to their management, to their shareholders, investment in an experimental program, in a developmental program.

Thank you.

Mr. **Nelson**. Dr. Reiff?

Dr. **Reiff**. I would like to comment in that regard. I like to praise Dr. Lennard Fisk, the new Administrator for Space Science and Applications. He has put out a new 5-year plan that involves priorities in several different areas. These have been mentioned by some of the previous speakers. But I think this kind of plan at that level is certainly crucial, and he should be very much commended for what he has done. Within each of the areas, he has possible new starts, and as the funding is available, then he will do as many of them as he can. I think that kind of 5-year planning is really key.

I would like to see some more commitment to long-range planning from the administration. I would like to see a science advisor named. I would even like to see the NASA Administrator confirmed.

Mr. **Nelson**. Well, hopefully, that is going to be coming shortly. Mr. Mattson, we have a fairly freewheeling style here, as you can see, and I interrupted your comments with questions, and then we just kept going on our dialogue. Would you like to summarize any additional comments that you have?

Mr. **Mattson**. Yes, thank you, Mr. Chairman. I will summarize. In summary, the task force emphasizes that proper planning in the form of a well-coordinated and well-executed space policy is as critical to the future of NASA's civil space programs as the budgets allocated.

The task force urges Congress and the administration to formulate long-range goals that expand manned exploration of space. Space Station should be the primary initiative which establishes our Nation's permanent presence in space.

Overall, the task force agrees with the administration's fiscal year 1990 budget priorities, while noting the following:

Spare parts and supplier problems may continue to hamper the shuttle availability through the 1990s unless active procurement of spares is begun.

A new shuttle booster should be developed after it is determined which of the alternatives will best serve the Nation.

The space station is the cornerstone of the Nation's space science and exploration programs and will allow us to apply our space technology and provide numerous returns to U.S. commercial and scientific investments.

Low-cost access to space is an essential ingredient in overall national space policy and a key element in maintaining a positive trade balance in the aerospace industry.

Space science is an important part of our national space policy. New starts and funding should be at a level which reflects long-range planning and international cooperation.

Privatization risks should be minimized where possible to protect industry from the hazards of shifting policies and priorities.

Finally, NASA's aging work force, coupled with its need to stimulate academic interest in advanced space technology, makes it imperative that NASA focus its efforts on educating and training engineers and scientists in space science to prevent deterioration of NASA's capable work force.

Thank you.

[The prepared statement of Mr. Mattson follows:]

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Statement of the
Task Force on Civilian Space Policy
of the
American Society of Mechanical Engineers
on the
National Aeronautics and Space Administration
FY 1990 Budget Request
Before the
Space Science and Applications Subcommittee
of the
Committee on Science, Space and Technology
U.S. House of Representatives
April 4, 1989

INTRODUCTION

The Task Force on Civilian Space Policy of the American Society of Mechanical Engineers (ASME) is pleased to present its views on the FY 1990 budget request of the National Aeronautics and Space Administration (NASA). This statement represents the considered judgement of the Task Force, a group of experts in the aerospace field, rather than an official position of ASME.

ASME is a nonprofit, educational, scientific and charitable society founded over 100 years ago. Membership in ASME exceeds 116,400 mechanical engineers, including 19,100 students. Because of the immense variety of applications for mechanical engineering, over twenty percent of our membership is directly or indirectly involved in aerospace technologies.

The Task Force is pleased with the previous Administration's proposed budget increase for FY 1990, from $10.9 billion to $13.4 billion, about one percent of the Federal budget. We note that much of the increase is intended for the space station and the space shuttle programs, accounting for two-thirds of the total. Additional areas of special note in the FY 1990 budget request include increased funding for Expendable Launch Vehicles up from $85 million to $169 million, and $342 million for NASA facilities refurbishment, replacement, and modernization. This last item is very important to maintain continuity within the nation's strategic research and development (R&D) effort.

The Task Force is concerned, however, that NASA's research and development programs may not be at a sufficient level to continue our nation's preeminent position in civilian space activities. New starts are a very small portion of the budget, accounting for less than one percent. In addition, budgeted increases in the space research and technology programs, which include the Civil Space Techology Initiative and the Pathfinder Program, do not meet original projections for the scope of these efforts.

We have focused our review of the NASA budget request on a number of areas of the space program where we believe improvements are warranted. In many instances, "improvement" does not necessarily translate into "more money," although there is a case to be made for increased funding in several areas. Our Task Force is primarily interested in pointing out the need for a consistent space policy. We believe proper planning in a long-range context and proper execution of these plans, can turnaround the erosion of our lead in space. Thus our comments will focus on the trends which we detect in the budgetary process, and highlight areas where a national policy is essential to successful execution of NASA's civilian programs.

NATIONAL SPACE POLICY

The Task Force applauds the legislative initiative of the 100th Congress to recreate the National Space Policy Council. We hope the new Administration will take this opportunity to give more visibility to Civil Space Policy and to revitalize and coordinate the planning process begun with the National Space Policy announced in February of last year. In this regard, the Task Force is concerned that the appropriate planning is not being reflected in the budget submissions to Congress which are required by law to be multi-year.

SPACE SHUTTLE

There is enormous pride throughout the nation in the return of our shuttle fleet to operational status. However, the job of providing a fleet of resilient reusable vehicles to meet the space transportation needs of this country has not been finished. The accelerated rate of launches anticipated for 1990 will stretch the current shuttle resources beyond their capacity in the forseeable future.

In terms of planning, the time is now to start providing for sufficient spares of long-lead shuttle hardware including structural components to minimize unscheduled down time. The proposed budget provides only $20 million in spares for the shuttle and offers no alternatives to the problems experienced last year when critical parts were not available to support the schedule. The Space Transportation System has been reduced to scavenging hardware from the existing fleet to support schedules, and further dependency on this type of activity could result in reduced probability of schedule recovery and launch resiliency.

In recognition of this nation's need to ensure that the space shuttle continues to offer the safest possible means of transportation for its crew, NASA is initiating the Advanced Solid Rocket Motor program. An alternative to the ASRM, a Liquid Rocket Booster, the LRB, has recently been studied by NASA. The LRB has the potential for even greater crew safety with the added benefits of cleaner environmental products with no attendent ammonium perchlorate shortfalls, improved performance and higher mission reliability. Furthermore, there are indications that such an LRB would be of value to the DoD fleet of ELVs, leading to the prospect of a cooperative development between the two agencies with the potential of satisfying the nation's need for a robust launch system. Before proceeding with the ASRM program that was created under the pressure of the post-Challenger environment, we believe it to be in the national interest to first more carefully assess which of the two systems would best serve this nation.

SPACE STATION

We were pleased to note the much needed support provided to the Space Station Freedom program as reflected in the FY 1990 NASA budget. This increase of $1 billion puts the Space Station on track for full operational capability by the mid 1990's. In order to remain on track, however, it is essential that the program receives consistent and adequate funding. We strongly urge Congress to provide the needed funding now, in FY 1990 and in future years.

America's past accomplishments in space have been impressive and have received worldwide recognition. However, the time has come when we must consolidate and apply the many past gains that we have made in the areas of space technology and exploration. Space Station Freedom provides that needed consolidation and ability to utilize our technology and expertise. For example, the Space Station and its associated man-tended free-flyers provides the node from which we can look back to Planet Earth to seek solutions to the many problems that currently plague our lands, oceans, and atmosphere. It will allow us to monitor our environment and service Earth Resources satellites dedicated to improving conditions on Earth.

Space Station Freedom will also provide a platform from which we can develop the technologies needed for the future expansion of man's presence in space. A facility in low Earth orbit is the proper environment to examine long duration space exposure. The economics of space transportation from low earth orbit to establish a Lunar Base or Manned Mars Mission are vastly improved over direct ascent from earth. Eventually, the spin-offs associated with artificial intelligence, robotics, and numerous advanced technologies will have many applications to benefit every man, woman and child in this country. The Space Station will provide America with a permanent manned presence in space and the servicing facilities required for future missions under our National Space Policy in addition to providing a link to to virtually all of our future goals in space as we move into the 21st century. Let's borrow a page from history and tap the vision of some of this World's great 15th and 16th century maritime explorers and get on with this Nation's next logical step into the frontier of Space.

NATIONAL AEROSPACE PLANE

We support the need for the National Aerospace Plane (NASP), a joint NASA/DoD program because we believe this program to be vital to our nation's competitiveness in aerospace in the 21st century. Conceptually, a future NASP would be able to cruise within the upper atmosphere at hypersonic speeds or ascend directly to orbit. It's potential capability to fly from the U.S. to Japan in about two hours could enhance commercial transport. As a space launch vehicle operating from conventional runways, the fully reusable and single stage to orbit aspects of NASP are believed to produce very large reductions in the cost to place payloads into orbit.

Technology developments in support of NASP are key to future low cost reliable space transportation systems and development of a flight test vehicle to demonstrate these technologies is essential. Technology spin-offs for the future can be comparable to those of the Apollo and Shuttle programs. Today, aerospace is one industry that has a positive trade surplus for the U.S. -- offsetting 1988's deficit by an estimated $17.8 billion.

SPACE SCIENCE

FY 1990 will be an important year for NASA in planetary exploration. Among the new programs planned for FY 1990 are the CRAF/Cassini missions. 1990 will also see the launching of Galileo, Ulysses, the Hubble Space Telescope, and the Gamma Ray Observatory. In addition, the Advanced X-Ray Astrophysics Facility (AXAF), a new start in FY 1989, is planned to proceed to a full scale development phase. The AXAF will complement the other great observatories we will have in Earth orbit and will provide us with insight into the origin of the universe.

The Comet Rendezvous Asteroid Flyby (CRAF/Cassini) mission, will provide excellent insight into the evolution of life and the solar system while helping to maintain U.S. leadership in the field of planetary science. The CRAF/Cassini mission will study the evolution of the solar system by examining asteroids and a comet (believed to be the most primordial matter in the solar system). It will also investigate the chemical evolution of life by studying the factory of organic compounds found in the atmosphere of Titan. The use of a pair of Mariner/Mark II spacecraft with a high degree of commonality will decrease the project cost by over $500 million when compared to the cost of building each spacecraft individually, and the contribution of The European Space Agency will reduce the mission cost further. The Task Force supports these Space Science programs and encourages the Committee to assure funding for these programs now and throughout their duration.

SPACE RESEARCH AND TECHNOLOGY

The Task Force strongly encourages the Committee to increase funding for space research and technology programs to a level commensurate with the importance of this area. For instance, Pathfinder, a new start in FY 1989, is a program to develop a broad set of technologies which provides the groundwork for our next generation of missions for exploring the solar system and is being severely underfunded. The program investigates four technologies: surface exploration, in-space operations, humans in space and space transfers. These technologies are critical to our understanding of the risks inherent in space exploration and overcoming those risks. Essentially, Pathfinder is formulating options and alternatives for human exploration of the solar system. Initial funding for this task was originally estimated at $100-200 million, rather than the FY 1990 budget of $47 million.

Low cost access to space will be key in future generations and technology development for effective low-cost approaches must be pursued if the United States is to maintain a competitive edge in space. It is essential that our laboratories, technical manpower and technologies be ambitiously pursued if we expect to be a world leader in future decades. We urge Congress and the Administration to place increased emphasis on studying risk-reducing solutions to NASA's future endeavors.

PRIVATIZATION INITIATIVES

In line with forthcoming observations, the Task Force notes the increased emphasis placed on commercialization of certain programs and facilities formerly budgeted by NASA. These proposals for privatization include:

o The Advanced Solid Rocket Motor (ASRM) production facility

- The Neutral Buoyancy Facility
- The Space Station Payload Processing Facility
- An Observational Instrument Laboratory at the Jet Propulsion Laboratory
- The Extended Duration Orbiter capability for the Space Shuttle
- The Flight Telerobotic Servicer for the Space Station

These facilities and programs are proposed to be financed by private industry or organizations at an estimated savings of $208 million to NASA. The Task Force supports policies which make good economic sense to NASA, and supports commercialization of space through the development of facilities such as the Commercially Developed Space Facility (CDSF) and Spacelab. However, the Task Force wishes to emphasize that the commercial marketplace for civilian space programs is still in its infancy. These programs will entail high economic or commercial risks which industry may be reluctant to assume, especially for programs whose out-year funding is not assured.

Over the past five years we have asked the Administration and Congress to urge NASA to increase participation of the private sector in space ventures. Among some of the private projects we have encouraged was a privately financed orbiter which now has received some NASA support. Some private ventures approved by NASA include the McDonnell Douglas biological processing project and the Fairchild Leasecraft, which have now been cancelled. After the January 1986 Challenger accident, many U.S. companies dealing with space went out of business or came very close to going into Chapter 11. In short, it appears that private companies desiring to participate in space with NASA are incurring great risk. We hope that the new thrust in the privatization of space will include some method where private industry is protected from the risk of pursuing a federally encouraged effort only to have support dropped at a later date. Space is still a risky marketplace in which to do business, and it will require government assistance until these businesses are somewhat self-supporting.

EXPENDABLE LAUNCH VEHICLES

We support the expanded utilization of ELVs for commercial payloads which free up the availability of the shuttle for special missions. Alternate means for launching all payloads via the mixed fleet concept makes good sense and good policy to assure that the nation's launch requirements are met. With the advent of several commercially available unmanned launch systems, the government has at its disposal the ability to plan for contingencies with launch resiliency. It should be noted, however, that the development costs for these vehicles have been amortized by the government over the last several decades and the costs to develop new vehicles on a commercial basis without government assistance, is prohibitively high.

TECHNICAL MANPOWER AND ENGINEERING EDUCATION

NASA's budget calls for adding 700 equivalent people to their staff in FY 1990, and we believe this to be a positive sign that our nation's space and aeronautics program will continue to grow. However, the breakdown in the 700 has not been announced. Are these scientists and engineers, or technicians, or computer scientists, or secretarial and other administrative personnel?

We are greatly concerned that with the diminishing number of U.S. students studying engineering (as well as the hard physical sciences) there will be a future shortage of key technical personnel. Currently over 50 percent of the U.S engineering doctoral students are foreign born. Unless more U.S. students are attracted to science and engineering this country will soon begin experiencing extreme difficulties supplying the necessary top engineering talent to staff organizations like NASA. Added to this manpower shortage is the problem of an aging workforce; more than 45 percent of the NASA workforce is eligible for retirement in the next two years. Therefore, we encourage the Committee to more aggressively address the technical manpower problem.

We enthusiastically endorse the establishment of the National Space Grant College and Fellowship program which seeks to broaden the base of universities involved in aerospace science and offers fellowships to train professionals in aerospace science. We also recommend that:

1) The ammount of the stipend and number of engineering recipients in NASA's Graduate Student Researchers Program be increased. The stipend in this program has been fixed for a number of years; and

2) The number of NASA Summer Faculty Fellowships in engineering be increased. This program has been very successful in familarizing engineering educators with advanced space technology.

SUMMARY

In summary, The Task Force emphasizes that proper planning, in the form of a well-coordinated and well-executed space policy, is as critical to the future of NASA's civilian space programs as the dollars allocated. The Task Force urges Congress and the Administration to formulate long-range goals that expand manned exploration of space. The Space Station should be the primary initiative which establishes our nation's permanent presence in space. Overall, the Task Force agrees with the Administration's FY 1990 budget priorities while noting:

o Spare parts and supplier problems may continue to hamper shuttle availability through the 1990s unless active procurement of spares is begun;

o A new shuttle booster should be developed after it is determined which of the alternatives will best serve the nation;

o The space station is the cornerstone of the nation's space science and exploration programs and will allow us to apply our space technology and provide numerous returns to U.S. commercial and scientific investments;

o Low cost access to space is an essential ingredient in overall National Space Policy and a key element in maintaining a positive U.S. trade surplus in the aerospace industry;

o Space science is an important part of our National Space Policy. New starts and funding should be at a level which reflects long-range planning and international cooperation;

o Privatization risks should be minimized where possible to protect industry from the hazards of shifting policies and priorities;

o NASA's aging workforce, coupled with its need to stimulate academic interest in advanced space technology, makes it imperative that NASA focus its efforts on educating and training engineers and scientists in space science to prevent deterioration of NASA's capable workforce.

The FY 1990 budget should be the start of a well-planned effort to strengthen NASA in R&D, international cooperation, and new ideas. Probably no time in its past has NASA had more promising opportunities and challenges, and the Task Force hopes this Committee will recognize the value of NASA's past contributions and the benefits of its continued health and expansion.

Acknowledgements

Members of the ASME Aerospace Division Task Force on Civilian Space Policy which developed this statement are:

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Dr. C. Dan Mote Jr.
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Mr. **Nelson**. And paying them an adequate salary.

Mr. **Perkins**. Mr. Chairman, if I could, just on that, I cannot help—I was listening to Dr. Fletcher today on National Public Radio and the comments he was making, and I was talking with my friend here about the same thing when we were talking about, by May 16, apparently we are going to be seeing some large numbers of retirements that are going to be coming about at NASA, and that we suddenly—I think there is another reason, apparently, because there is the 2-year prohibition after this fiscal year, so they are going to have to get out while they can, but the question is, how do you think this exodus, or apparently mass exodus, is going to affect the ongoing operations of NASA?

I would be interested to hear some comments. Do you have any idea about the depth of the problem yet? Do you have any feel for it?

Mr. **Simpson**. Yes. Basically, since about 1966, NASA's work force has remained constant. They were not able to hire anybody. They were laying people off in the late sixties and early seventies. At its peak, the number of civil servants at NASA was something like 35,000 people in 1965 or 1966. That went down to about 22,000 or 23,000 people by about 1973, and it stayed there. So, basically, since 1965 NASA has not been able to hire any civil servants.

There is a plus and a minus. You will be getting rid of some dead wood. You will also be getting rid of some very talented and capable people, and I hope they are picked up by private industry.

Mr. **Perkins**. Well, you are getting rid of a lot of them, apparently.

Mr. **Simpson**. Yes.

Mr. **Perkins**. The question is, how is that going to impact upon the operations of the programs?

Mr. **Simpson**. You are going to have a large number of promotions to some fairly young people because there is nobody in between. NASA has a lot of people in the age group—well, some people in the age group—from, say, 20 to 30. But then from about 30 to 50, they are down, and then over 50 they have a lot because of this window when they could not hire anybody, and this is going to create a problem, undoubtedly.

Mr. **Perkins**. The over-50s are going to retire, and we are going to have to promote all the others from the under-30s to the same jobs that were held by the over-50s.

Mr. **Simpson**. Or bring them in from private industry.

Mr. **Perkins**. Or bring them in, which is going to be difficult because of the salary considerations.

Mr. **Simpson**. Right.

Mr. **Perkins**. So, in essence, what you are telling us is that we are losing an awful lot of experience. Some of it may be dead-wood experience, but there is an awful lot of talent that we are losing as well.

Mr. **Simpson**. Right, a lot of good, dedicated people.

Mr. **Perkins**. And I am just wondering what kinds of effects this is going to have on the operation of our programs. Do you have any feel for it? It cannot be positive, can it?

Mr. Simpson. It cannot be positive totally, but somewhat. I think that without a challenging new goal for the space program, however, it will not make that much difference. [Laughter.]

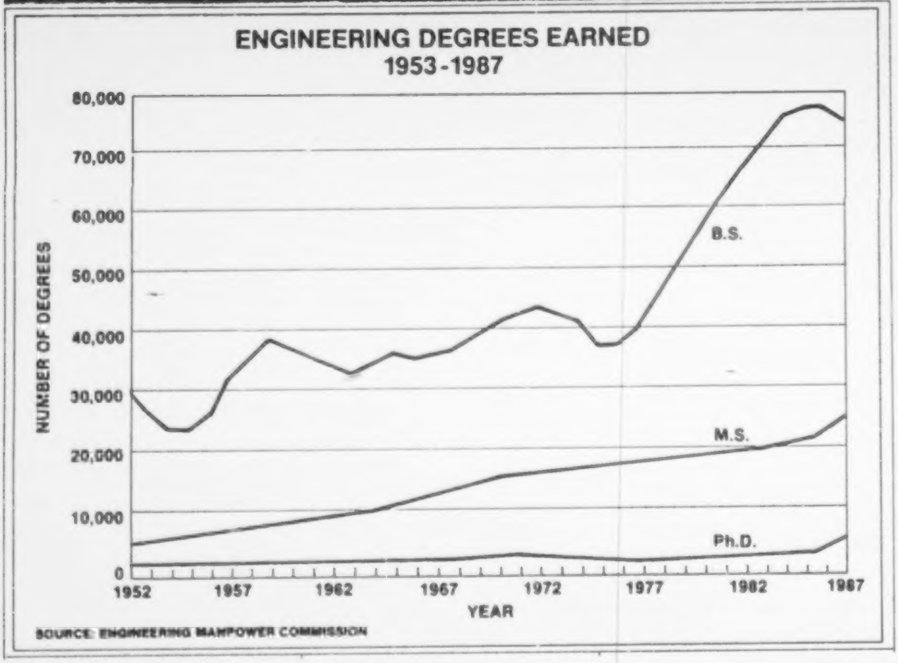
I think that, to a certain extent, that is one of the "tired blood" problems. If you said that you were going to the Moon or to Mars and you did not even put a deadline on it, if you just told them that they had this forward thing to look at, rather than saying that, well, we are going to cut your budget some more this year, then you would get a much more positive response both inside and outside NASA.

Mr. Perkins. You think it is the lack of a long-term goal that is giving us some real problems?

Mr. Simpson. Yes. And it is also one of our problems with hiring and educating engineers and scientists. Unless you have that long-term goal, there is no point in educating large numbers of engineers and scientists. There are probably more engineers graduating today than there were during the 1960s at the time of the Apollo program. I think that is in an Aviation Week article back around December 15 or so.

[Chart from article follows:]

U. S. AEROSPACE/DEFENSE ENGINEERING MANPOWER



SOURCE: ENGINEERING MANPOWER COMMISSION

So I am not worried about the number of engineers graduating today in terms of there being a real crisis. In fact, I am concerned the other way because, with the cutbacks anticipated in defense, the overall aerospace industry is probably going to go into a period of somewhat decline and stagnation.

Mr. **Perkins**. Thank you, Mr. Chairman. I am sorry to interrupt.

Mr. **Nelson**. Dr. Reiff, in our freewheeling style, we need you to tell us about auroras.

STATEMENT OF DR. PATRICIA H. REIFF, SENIOR RESEARCH SCIENTIST, DEPARTMENT OF SPACE PHYSICS AND ASTRONOMY, RICE UNIVERSITY; AND MEMBER, SPACE SCIENCE WORKING GROUP, ASSOCIATION OF AMERICAN UNIVERSITIES AND NATIONAL ASSOCIATION OF STATE UNIVERSITIES AND LAND-GRANT COLLEGES

Ms. **Reiff**. Well, I am not here just to tell you about auroras, but that was just an example that I brought to show you some of the exciting science that is going on that affects us all where we live.

Unlike my distinguished colleagues, I am a grubbing little scientist in a university and dependent day by day on all the proposals that I write and all the paperwork that I have to shuffle, and in that sense, I can tell you, a 3-year grant is a lot more fun than a 2-year grant. [Laughter.]

But the aurora that we had that was visible from Texas just a couple of weeks ago is just an example of one of the things that has caught the public eye, and it also is an example of a place where auroral physics, which you think of as being fairly esoteric, can actually hit you where you live.

This particular aurora—I have an ultraviolet image from Dynamics Explorer there posted on the easel. That is a southern hemisphere, for the people who are good at standing on their heads. You can actually see the tip of South America coming in from the top. That ring of the aurora is the largest auroral ring ever recorded by this particular spacecraft. It is over 50 percent bigger than the largest other one on record.

You can see, at the bottom of that image, New Zealand over at about 7:00 o'clock and the bottom edge of Australia between 5:00 and 6:00 o'clock. Actually, there were auroras visible over Tasmania and even Sydney and Melbourne, which are normally way out of the auroral zone.

From the United States, I have an image here that was taken from the Defense Meteorological Satellite Program. David can show the stands and I will show the people up front. This is taken by the Defense Meterological Satellite Program, which is a spacecraft that goes from north to south looking at its feet, and because it is fairly low altitude, 800 kilometers, it sees a strip only about 1,000 kilometers wide. So this is one orbit and this is the next orbit, sort of like a LandSat only for meteorological purposes, and you see the main auroral belt extending across Philadelphia.

You can see California here and Florida here. This is visible light, so you can actually see the cities. You see the light pollution that drives us astronomers nuts. Here is Chicago, just barely out from underneath the auroral belt.

This cloudy area here on this part that looks like clouds is actually a big red aurora from the dumping of the Van Allen belts. Just a couple of hours earlier, that was over Texas and was observed in Texas. I have gotten some images of the Aurora from Texas that were shot, but because my testimony got moved up a day, I could not get them from the photo lab in time, so I apologize for that.

Mr. PERKINS. What do you mean, a dumping of the Van Allen belt? I don't understand that.

Ms. REIFF. Well, the Van Allen belt is the trapped energetic——

Mr. PERKINS. I know what it is.

Ms. REIFF [continuing]. And what happens with a big solar flare, the Earth's magnetic field, which is a magnetic bottle in space but it does not have walls, the big blast of particles from solar wind compresses the whole thing, and so the inner parts come in and the auroral belt, which is normally at the poles, get moved down, and everything gets shoved in.

Mr. PERKINS. I see.

Ms. REIFF. And the Van Allen belts, because they were close to the circles already but trapped, suddenly find themselves not trapped any more. This can actually be a hazard to astronauts. You think of 30 degrees' shuttle orbit as being very safe from energetic particle bombardment, and yet I would not have recommended any EVAs on this particular mission. As it turned out, they did not see the aurora; they were in the right or wrong place at the right time, depending on which way you look at it.

But there was a big power outage in Quebec that was 20,000 megawatts of capacity which was blown for 9 hours because of the induced electrical currents from this aurora. The storm itself is 1 million megawatts of energy. Of course, you cannot harness it yet. So you can imagine that it can induce currents, and it has been known for many years to induce currents in the Alaska pipeline. It helps the oil move faster because it warms up the pipes.

But these kinds of things are really exciting to a space scientist. Being in a laboratory without walls and with uncontrolled experiments, we have to have a spacecraft up and available to take the data when it happens. One thing that has happened in the past is that our spacecraft have lasted longer than they were designed, which is terrific. On the other hand, you have a certain funding profile for each program, and what happens is that the funding profile says you are going to stop funding this mission after 4 years, and yet here is the spacecraft taking good data after 8 years.

This instrument right here, this whole spacecraft, is put on a campaign mode because, to save a few million dollars a year, it is only turned on when important things happen. Luckily, we saw the flare a day in advance so we could turn it on, but what if something had happened that we did not have notice? We would have lost that data forever.

This DMSP data, for example, is taken by the Air Weather Service to aid in weather forecasting. Up until now, it has always been saved on film for archiving that we could use it. Now they are talking about not even using a film archive. The Snow and Ice Data Center said they might be interested in doing a video archive of it for a couple of hundred thousand dollars a year, and yet it is not clear that the money is going to be available to do that.

So it is clear that we need to make the most out of what spacecraft we have. We have a big investment in these instruments, and we need to take the biggest scientific advantage of them that we can, and with the erosion of funds that we have had over the last few years, it has really impacted our ability to train scientists, to train graduate students, and I think this new budget is a good turnaround in that long erosion trend, and I commend Len Fisk very heartily for balancing the program of big science and little science.

So the long and the short of it is that we need the big science, we need the little science, we need to set priorities, and I think they have done an excellent job. On the other hand, if there is not a lot of fat in this budget, there are a lot of things like that for little amounts of money that are not being done, and if you do something like reinstate ACTS without the dollars, it is going to come out of somebody's hide, and I don't want it to be my hide.

The STORE program, which was an ambitious and technically very challenging test of relativity, was zeroed out this year, even though it had over a half-million-dollar commitment of university funds from Stanford University. I think it was a case that they had the rug pulled out of them that they were not expecting, and that is not a good way to do business. I think we have to make these decisions and then try to stay with them if we can.

But again, if we reinstate it, we need to find the money for it. If you add or restore major programs such as ACTS or STORE without the corresponding addition of resources, it would severely damage the strategic plan and the orderly accomplishment of ongoing programs, and it may mean no new start for CRAF.

So I think Len Fisk, at least within OSSA, has done a lot of the hard choices and has really tried to balance the budget very tightly, and I would hate to see any money removed from his programs.

Well, I will stop.

[The prepared statement of Dr. Reiff follows:]

NASA SPACE AND EARTH SCIENCES PROGRAM

by
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on behalf of the
SPACE SCIENCE WORKING GROUP
of the
Association of American Universities
and the
National Association of State Universities and Land-Grant Colleges

before the
Subcommittee on Space Science and Applications
of the
U. S. House of Representatives
Committee on Science, Space and Technology

April 4, 1989

Mr. Chairman, Members of the Subcommittee, thank you for this opportunity to testify on the subject of NASA's Space and Earth sciences program. My name is Patricia Reiff, and I am a working Research Scientist in the Department of Space Physics and Astronomy at Rice University, and as such my research associates, my graduate students, and I are fully dependent on research funds from NASA and from the National Science Foundation. I am speaking here today as a member of the Steering Committee of the Space Science Working Group (SSWG) of the Association of American Universities. I am testifying on behalf of the Association of American Universities and the National Association of State Universities and Land-Grant Colleges, whose members represent most of the major research universities in the United States.

After the prolonged hiatus in the U.S. space program, the next 12 months will initiate a dazzling return to exciting accomplishments for the space sciences. Later this month, NASA will launch Magellan, the first U.S. planetary mission in more than a decade, which will map the surface of Venus. In close succession will be the launches of the Cosmic Background Explorer, the Galileo mission to Jupiter and its satellites, and the first two of the Great Observatory series, the Hubble Space Telescope and the Gamma Ray Observatory. In August, Voyager 2, launched 12 years ago and continuing to yield important data, will send humankind the first spacecraft data from Neptune, presently the most distant planet from the sun. The confluence of all of these scientifically outstanding and technologically challenging missions marks the beginning of a new era for the space sciences since Challenger disaster.

Poised as we are on the threshold of an new chapter of discovery for the U.S. space sciences, it is timely to restate the rationale for a vigorous national civilian space program. In the context of this rationale, the SSWG would like to offer its view of the FY 1990 NASA budget before you.

A VIGOROUS SPACE PROGRAM AND NATIONAL PRIORITIES

As an element of national policy, a strong and active space program provides a highly visible demonstration of this nation's scientific and technological prowess. At an intellectual level, space science epitomizes our innate inquisitiveness about our environment and our place in the cosmos. At a technological level, space presents profound challenges that drive industrial creativity. At an emotional level, space offers the unique opportunity for all of us to experience the thrill of exploration of an expanding frontier. The U.S. space program must achieve a balance among these perspectives, which calls, in turn, for a balance between science and applications, between manned and unmanned activities in space, and between infrastructure and new initiatives.

As the scientific exploration of space moves outward to distant planets and galaxies, the growing public concern over the fate of our own planet underscores the crucial role of space science for understanding the workings of Earth. With issues such as the deterioration of the ozone layer and secular global warming drawing accelerated worldwide attention, the space-science community will bear an increasing responsibility to provide the technical context for political decisions at national and international levels. Our national space program must continue to seek the new data necessary to provide this context.

The most recent manifestation of public interest in space is found in the latest sequence of solar flares, which resulted in auroras visible as far south as Brownsville, Texas on March 14. These auroras, not only a gorgeous curiosity, have serious effects on the ground. The electric currents that the aurora induced in the Quebec electrical system resulted in the loss of 20 thousand Megawatts of generating power for over nine hours, plunging millions of homes into darkness. Interestingly , the amount of energy contained in the auroral storm, could it be harnessed, amounted to over a million Megawatts! Other states with power upsets included New York and even New Mexico. Many spacecraft had electrical upsets, including the TDRSS launched by the flying Shuttle mission. (Incidentally, the low-latitude shuttle orbit is generally considered safe for astronauts; however, the dumping of the energetic Van Allen belts during the storm, which caused the lowest-latitude blood-red displays, could pose a safety hazard for extra-vehicular activity).

I have brought with me some photographs that show images of the aurora taken from space; the highest resolution black and white images are taken from the Defense Meteorology Satellite Program (DMSP)[1] and show the main auroral belt over Philadelphia and Detroit; the large-scale color images from space are ultraviolet images of the southern auroral oval from the Dynamics Explorer-1 Spacecraft.[2] In that image (taken 14 hours later than the DMSP images) you can see auroras over Sydney and Melbourne, Australia. The portion of the earth's surface inside the auroral ring is over double its average size and exceeds by 50% the largest aurora previously seen by that spacecraft. Global images like these are crucial for our study of large-scale auroral and ionospheric processes, yet are in danger of being lost as a scientific resource.

Mr. Chairman, I believe that NASA's space science program should be viewed in the context of a current theme being widely discussed throughout the science community and of particular concern to Congress and this Committee: the need to have a process and accepted manner of setting scientific priorities. This debate is the result of the fact that the cost of conducting leading edge science in every discipline exceeds available resources. This truism has forced policy-makers to choose between funding fewer programs at adequate funding levels or pulling along a greater number of programs "by their bootstraps." This Committee has responded to this challenge by consistently authorizing funding for NASA's space science program at responsive levels, while simultaneously insisting that NASA provide the Committee with a straightforward, cross-cutting set of priorities for future scientific missions. It is in this context that I would like to commend the work that NASA has done in the form of the Office of Space Science and Applications (OSSA) Strategic Plan. Under the leadership of NASA Associate Administrator for Science and Applications, Lennard Fisk, NASA's science program has made substantial progress toward establishing far-sighted and balanced priorities for our space science program. I can tell you that, as a practicing scientist, the stability and predictability that this provides the entire community is most welcome.

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[1] Attachment 1. Courtesy of Major J. Schmitt of the Air Weather Service

[2] Courtesy Dr. L. A. Frank , University of Iowa

A robust space science program also can help address another pressing national priority – the need to reverse the declining interest and skill in science and mathematics in elementary school children. It is essential to strengthen those national programs that capture the scientific and technical imagination of our population. Our space program has been and can continue to serve as a catalyst in this area. One need look only at the continued large crowds at the National Air and Space Museum, public fascination with discoveries of a new supernova or the rings of Uranus, and the consistently high turnouts to view the space shuttle launches and landings to recognize the power of space exploration to drive the curiosity of child and adult alike.

Thus, harnessing the curiosity to attract the next generation of scientists and engineers should be an important objective of our national space program. This is particularly true from a university perspective. After all, universities have traditionally provided the backbone for space science research in this country and are a major source of new scientific theories and of new ideas for spacecraft instruments. At least equally importantly, universities are the principal source of new scientific talent, through the training of graduate students and postdoctoral researchers. The declining opportunities in the space sciences over the past several years have posed serious obstacles to attracting and retaining the best young scientific minds. As a result, the generation of young space scientists who will conceive and carry out the next set of scientific missions is dangerously underpopulated. For example, At Rice University, despite the fact that my research our proposals receive consistently good reviews, I have had to cut my staff in half, and in addition my computing and publication budgets have been severely curtailed. The consequences of are this are 1) that we are now publishing only four scientific publications a year, rather than ten, 2) we are able to train fewer graduate students, and 3) it appears that we will not be able to do a full analysis of the March 14 aurora, because funding cutbacks will probably cause the Dynamic Explorer team to be disbanded before a full analysis can be accomplished. A vigorous and broadly conceived U.S. space program will reverse this corrosive trend.

THE PROPOSED FY 1990 NASA BUDGET

I would now like to focus on the proposed FY 1990 NASA budget in the context of how responsive it is the various objectives of the space program. The SSWG commends NASA and President Bush for submitting a FY 1990 budget which advances several areas of the space program of importance to the university space science community. We are heartened by the continued program development in the recent major new starts for AXAF and Global Geospace Science. This orderly implementation of the OSSA Strategic Plan gives our best assurance for recapturing U.S. leadership in space science. Of special importance to the university space science community are the new initiatives in the balloon and suborbital rocket programs and the augmentation of the Explorer line to fund the new Small Explorer missions. These relatively modest programs are of an ideal size for strong university participation and have time scales commensurate with the training of graduate students and the career development of young faculty. We particularly applaud the procurement of expendable launch vehicles which will provide the U.S. space science program with frequent and assured access to space.

The SSWG strongly endorses the proposed new start for the CRAF/Cassini mission and the essential increases in the research and analysis (R&A) components of the OSSA budget. The CRAF mission will provide the first long-term study of a comet, including *in situ* analysis of material thought to be little altered from the earliest beginnings of the solar system. The Cassini mission, to be carried out in cooperation with the European Space Agency, will give us in-depth observations of the atmosphere, magnetosphere, rings, and moons of Saturn, as well as chemical analysis of the thick atmosphere of its intriguing, haze-shrouded moon, Titan. Both missions, coupled with other "new starts" on line in the strategic plan, will serve to maintain a vigorous program of U.S. solar system exploration well into the next century.

The increases in the R&A components of the OSSA budget reverse a long erosion of support for basic research, analysis and management of data from past missions, and advanced technology development - all essential ingredients of the efficient planning for the next generation of activities in space. The increases are particularly welcome in the space life sciences, which bore a disproportionate and debilitating share of the budget cuts in FY 1989. Programs which had been originally slated for this year, including development of a centrifuge facility, and planning for initiatives in space biology and extended duration crew operations, can finally begin in FY 1990. Indeed, the R&A programs are the lifeblood of university space science in its role of attracting and training the next generation of engineers and scientists. We also commend NASA for continuing its support of the NASA Graduate Research Program, which funds 245 new and continuing awards to outstanding students pursuing career interests in space-related fields of study.

The overall FY 1990 NASA request is $13.3 billion, a 22% increase over FY 1989, while OSSA's portion is slated for a 9% increase, from $1,833 million to $1,995 million. Given the tight constraints on the federal budget, we view this budget submission as a serious commitment from the Administration that leadership in space is an important policy priority. However, a close analysis of the OSSA portion of the budget shows that it is extremely tight, with little or no flexibility for unanticipated events or opportunities. The missions operations and data analysis budgets, for instance, show large increases in FY 1990, but these increases will principally support the missions to be launched in the next 12 months. The positive budgetary steps notwithstanding, the SSWG is distressed about several aspects of the budget as submitted.

Mr. Chairman, as the spokesperson today for the primary university-based policy group concerned with NASA, I would like to raise an issue of central concern regarding the way universities work with NASA. As you know, universities often make significant investment in people and facilities to support NASA goals. While there is never a guarantee that the government will continue to fund every program, there is an understanding that meritorious programs, which are endorsed by peer-review, will usually receive continued support.

It is in this light that I wish to bring to your attention the proposed cancellation of the Shuttle Test of Relativity Experiment (STORE) program. This program, often referred to as "Gravity Probe-B," is designed to test Einstein's theory of relativity. This project, which encompasses large advances in science and technology, was contracted to Stanford University in FY 1985 and is a two-phase flight program leading to a 1995 mission. This approach has received the enthusiastic support from the National Academy of Sciences, NASA, Congress and the OMB. Since contracting with NASA in 1985, Stanford University has dedicated nearly half an acre of laboratory and office space to Gravity Probe-B and has invested over $650,000 in this program. This program has heretofore been a model for a NASA-university partnership directed toward achieving a technologically challenging and scientifically fundamental goal. However, despite these commitments and a series of superior external evaluations, NASA, for macroeconomic reasons, has proposed "zeroing" this program in the FY 1990 budget. If this program is canceled, it may have long-term consequences on future NASA-university cooperative ventures. The SSWG requests that Congress find a mechanism for restoring Gravity Probe-B by adding $25M to the OSSA request for this program.

Two other initiatives, modest in cost but large in importance, were also not included in the budget request: the Earth Probes spacecraft series (the first of which would monitor the temporal and spatial variations in the Earth's ozone layer) and a program to place U.S. experiments on international missions. The delay or loss of the ozone mapper is serious given mounting concern over the ozone depletion problem, and candidates for later spacecraft in the series to monitor ocean color, to map the Earth's geopotential fields, and the measure global rainfall represent key elements of a coordinated Mission to Planet Earth. The loss of foreign mission support means that unique opportunities for low-cost U.S. participation on foreign missions, including a powerful Soviet X-ray telescope, may be lost. In addition, international collaboration saves wasteful duplication of effort.

Finally, because of the tightness in the budget, the addition or restitution of major programs, such as the Advanced Communications Technology Satellite, without the corresponding addition of resources would severely damage the carefully crafted OSSA strategic plan and the orderly accomplishment of ongoing programs. The impact on other elements of the OSSA budget could be very significant.

Funds to support currently operational spacecraft are dwindling despite opportunities for measurement of new phenomena, particularly in the space physics field. For example, I note that both types of image data that I have shown are in jeopardy for continued use by the scientific community. The DMSP imaging data are paid for by the Air Weather Service to aid in weather forecasting, yet many DOD, NSF, and NASA research projects have used the images to get high-resolution information of auroral morphology. The Air Weather Service has informed us that after this year, as a cost cutting measure, neither digital nor film archiving will be made of these images, with the result that all of their data will be lost to the space science community. These kinds of losses of valuable data are tragic, since the amount of money to preserve the data is quite minimal (about $200,000 per year in the case of DMSP).

Mr. Chairman, I would like to take the liberty of reminding the Committee about the need for balancing the space science program with the rest of NASA's program. In order to avoid repeat mistakes learned from the shuttle program, Congress has decided that one way to maintain a balance between hardware development and science is to mandate that at least 20% of NASA's R&D and space flight budgets be allocated to space science programs. This sentiment is reflected in the FY 1988 Appropriation for NASA which stated, "... the conferees note that the Agency is committed to maintaining funding for science and applications at not less than 20 percent of total NASA resources. Although to date NASA has honored this commitment, the conferees are concerned that further budget constraints could negatively impact unmanned activities." (H.J. Res. 395: Conference Report 100-408, page 856.) This Committee has actively supported this approach and NASA has concurred. This policy helps ensure that space science, the basis of America's future in space, will not be asked to assume the burden of cost over-runs or administrative planning errors in other parts of the space program.

The SSWG is concerned that the proposed budget for Space Science and Applications may be below the minimal level of support necessary to make the most effective scientific use of the nation's scarce space missions. By submitting a budget for OSSA which is less than the 20%, NASA, in effect, undermines the policy established by the Congress to guarantee the availability of funds sufficient to maintain the minimally necessary level of research support, including payload flight opportunities.

We continue to believe in the soundness of previous NASA and Congressional reasoning that set the minimum budgetary investment in space science at the 20 percent level. While the SSWG recognizes the strong fiscal constraints imposed by the Brobdingnagian federal deficit, we nonetheless urge Congress to restore the appropriate balance to our nation's civil space program. Specifically, a return OSSA to the 20 percent level would permit the restoration of Gravity Probe-B and the initiation of the Earth Probes series, would enhance international scientific cooperation in space exploration, and would provide needed increases to mission operations and data analysis budgets.

SUMMARY

With the proposed FY 1990 budget, NASA will continue its implementation of a long-term plan that will return this nation's program in space science to one of vision and vitality. The plan remains responsive to the recommendations of NASA and NAS scientific advisory committees. The FY 1990 budget continues to aim for balance among support for ongoing programs, diversification of the launch vehicle fleet for space science missions, increased support for research and analysis and technology development, and new initiatives in life sciences and solar system exploration. With modest and carefully targeted additions to the space science program, this budget represents a major step toward assuring a fully balanced program of space science and applications and will accelerate American efforts to regain leadership in space. At the very least, we request approval of the Space Science and Applications budget as submitted in the Bush budget. Hard choices have already been made and squeezes have been effected in order to provide for new missions. A major cut (or a restoration of a program without funds) would result in a drastic setback to the space science program.

Thank you again for the opportunity to present this testimony. I would be pleased to answer any questions.

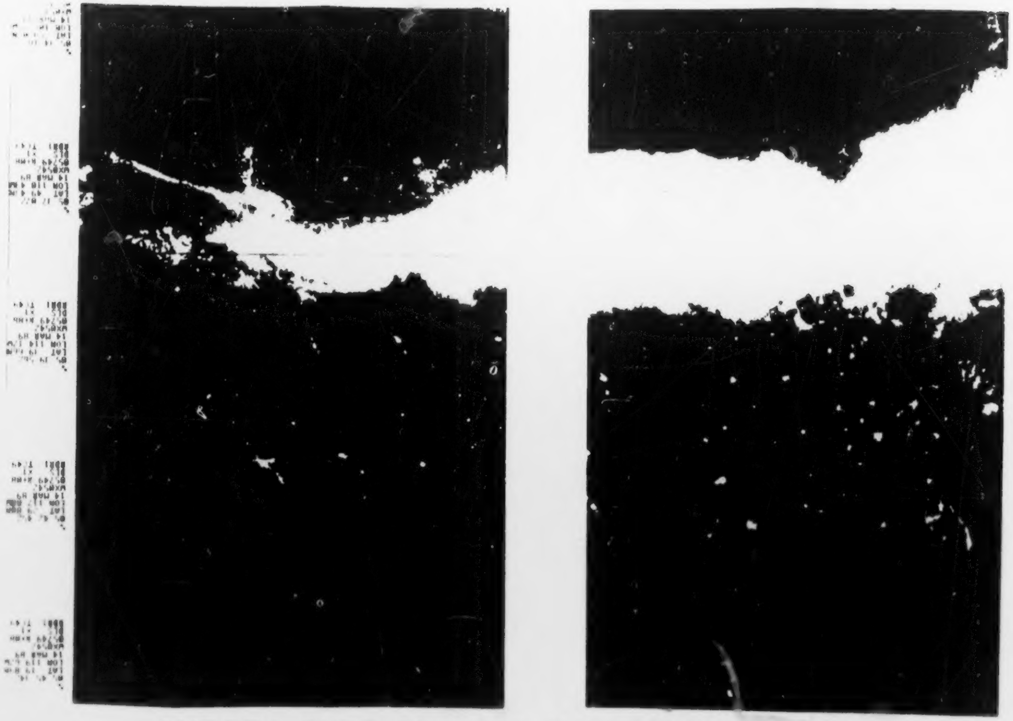
Biographical Sketch

Patricia H. Reiff

Dr. Patricia H. Reiff was born March 14, 1950 in Oklahoma City, Oklahoma. She received her B.S. degree in Physics from Oklahoma State University in 1971 and her M.S. and Ph.D. degrees in Space Physics and Astronomy at Rice University in 1974 and 1975, respectively. She spent one year as a National Research Council Resident Research Associate at Marshall Space Flight Center, Huntsville, Alabama, and has spend the remainder of her professional life teaching and performing research at Rice University, including a five-year service as Assistant Chairman of the Department of Space Physics and Astronomy. Her husband, Thomas W. Hill, is also a professional space scientist; they have a 3 1/2 year old daughter and two year old boy/girl twins.

Dr. Reiff's principal research interest is the Earth's magnetosphere, particularly auroral physics. Her Ph.D. thesis involved analyzing data from the Apollo 14 Lunar Alsep plasma detector. She has also been involved in data analysis from the Atmosphere Explorer spacecraft, and is a Co- Investigator on the HAPI plasma instrument on Dynamics Explorer. New missions in which she will participate include being a Co-Investigator on the magnetometer instrument on the Polar spacecraft of the Global Geospace Science Mission, a Co-Investigator on the electron detector of the Cluster Mission, and a Co-Investigator of the ion mass analyzer on the Comet Rendezvous Mission. She has served on a number of advisory panels, and is currently a member of the Advisory Committee for Atmospheric Science of the National Science Foundation, an associate editor of Reviews of Geophysics, a member of the Houston Metro Astronomy Council and the Rice University Research Council. She is author of numerous refereed journal and book articles and is writing a book on breastfeeding.

ATTACHMENT 1



AURORA OVER CENTRAL U.S. MARCH 14, 1989

This pair of images shows the aurora observed over a large portion of the United States, the evening of Monday, March 13-14, 1989. The result of one of the largest flares on record, the main auroral belt spans across the central U.S. (causing a major power outage in Quebec), and patchy red aurora was observed as far south as Brownsville, Texas, (seen in the right-hand image as clouds over the Carolinas). The right hand image was taken from the Defense Meteorological Satellite Program imager (courtesy Major Jill Schmitt of the Air Weather Service) at 0400 UT March 14 (just premidnight local time); the left-hand image, was taken one orbit later (0540 UT, also near midnight). This visible-light imager plainly shows light pollution from U.S. cities.

Mr. **Nelson**. Let me ask you about that picture. Now, that is taken from a satellite that at that moment is somewhere below the South Pole?

Dr. **Reiff**. That is correct.

Mr. **Nelson**. About how many miles away?

Dr. **Reiff**. It is about three Earth radii above the surface.

Mr. **Nelson**. How much?

Dr. **Reiff**. Three Earth radii.

Mr. **Nelson**. Oh, I see.

Now, describe for us—the yellow in the picture is the energy that you are seeing. Since you show the tip of South America, you are looking there at the South Pole. Describe for us the various colors and what they mean in that photograph.

Dr. **Reiff**. Well, this is actually a false color. In other words, this was taken in ultraviolet light, which does not have a color per se, and so the intensity of the ultraviolet that reach the imager is shown as a brighter yellow. The brightest yellows are the most intense ultraviolet; the blackest are the least ultraviolet.

Of course, the outlines of the continents in that are just added on just for scale, whereas, in this picture, the cities are really the cities. These are really visible light pollution from the cities themselves. You see the continents actually from the visible light. Because people do not generate much ultraviolet light at home, you do not see the cities for scale in an ultraviolet image. The advantage of ultraviolet is that it shows where the most energetic part of electrons hit.

Mr. **Nelson**. All right. Then that is what my question is. If the most energy is there, which would be at the rim of the Earth as you are looking at it from this bird's-eye view, out in space looking back at the South Pole, how can that be, because of the magnetic field that would normally repel that, where you would get your greatest energy at the poles? So why wouldn't we see the light color there closer to the pole instead of at the rim of the Earth?

Dr. **Reiff**. Well, that actually was the very first theory of how the aurora came about from a fellow called Stirmer, who was a Norwegian, and he had just the same point. If you had a dipole field which was unconfined, then the easiest way to trace a particle orbit out into space would be exactly at the poles because the aurora should be the brightest at the magnetic pole and get dimmer as you went more Equator-ward.

But in fact what happens is that the Earth's magnetic field is not a simple dipole that stretches uniformly into space. Rather, the Earth's magnetic field looks more like a comet. You have a squashed-in part on the day side and a stretched-out part on the night side, and the boundary between the day-side part and the night-side part, if you mapped that entire boundary down to the ground, that boundary gives you a circle, and it is that boundary where the particles can get the easiest access.

One way of thinking of it is that the magnetic pole field line, which in simple dipole would go into space, actually goes way down the magnetic tail and in fact does not reach the solar wind until way downstream. It is these magnetic field lines at this ring that are actually in the closest contact with the solar wind because they are the ones that map to the boundary of the magnetosphere. It is a fascinating part of magnetospheric physics, which is what I do for a living.

Mr. Nelson. And so from this photograph here, where you are showing that the greatest energy is just north of Chicago—is that correct, on that photograph?

Dr. Reiff. That is correct.

Mr. Nelson. Well, then, if you were in a space shuttle at 57 degrees inclination, you would be in deep trouble.

Dr. Reiff. You might be, yes, certainly. The energetic part of the solar flare particles come within 20 minutes. The part that causes the aurora is the 20-kilovolt-type particles, and they are really not as hazardous to man in space as the most Energetic Particles. Unfortunately, the most energetic particles are the ones that give you the least amount of warning.

So you certainly do have to be cautious about polar orbiting manned spacecraft, and you have to either carry enough shielding or you have to have some sort of reasonable escape system. Auroral type energies, you can—as long as you stay inside the vehicle, you are pretty much protected.

Mr. Nelson. Are there any questions from the remainder of the committee members? Mr. Tanner, did you have any comments or questions?

Mr. Tanner. Thank you, Mr. Chairman.

On an unrelated matter, if I might, all of us have read and heard and seen and been told about the ozone problem, and it is my understanding that there was a request made for some funding somewhere in the neighborhood of $10 million for the Total Ozone Mapping Spectrometer, TOMS. That apparently has been deleted.

How serious, one, is the ozone deterioration? How rapidly is it occurring? And should this reinstatement, perhaps, I guess, of the funding for the TOMS, which I understand will take the place of a satellite that is about to die that gives us this information, should that be a number-one priority of this country?

Dr. Reiff. Well, I think ozone is certainly a key issue, and that is just one of many examples where space science really affects how we live. The other, of course, is the global greenhouse warming, both of which are ultimately related to human activities on Earth.

My understanding is that TOMS was not designed to replace the current Nimbus, that there is another Nimbus on line to replace the current Nimbus, that it would be the one after that. So I don't know the details of how serious it is for a one-year slip in TOMS because there is, in my understanding, another Nimbus on line ready to go.*

But it is clearly true that these kinds of issues can make tremendous financial impact on the country. Do we force people to stop using fossil fuel because of the global warming? Do we force people to stop using chlorofluorocarbons in their automobiles, which is a tremendous waste of chlorofluorocarbons? We all have our air conditioners, at least in Texas.

So these are issues where there is a profound economic impact on some of the science that is done, and the numbers that I heard indicated that the amount of research being supported in actual aeronomy of ozone itself and how it responds to man-made gases is like half-a-million dollars a year of research dollars—I mean, it is very small—compared to something which can have billions of dollars' worth of impact on industry not only in the United States but around the world.

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*See appendix 8, p. 1188.

And so this is something we really need to invest the money in to get the science down if we do not want to restrict a billion-dollar industry unnecessarily. So we need to really know the chain of command first before we put in the regulations, and in that case we really do need to make this 1 percent investment in science to pull that off.

Mr. TANNER. Do any of the rest of you have comments?

Mr. GREY. I would just like to support something that Dr. Reiff just said, and that is, an investment of a relatively small amount of money in improving the computational models and the observations that we make that could lead to decisions that have significant economic impact is something we do not pay enough attention to.

There is a scientist—Mr. Hansen, I think—at Goddard Space Flight Center who is doing most of the modeling for the greenhouse effect. He is doing it on a 17-year-old computer because that is the best he has available to him. Twenty million dollars to buy him a Cray would probably allow him to do a heck of a lot more modeling, and more accurate modeling, and more comprehensive modeling, of something as significant as the greenhouse effect, and it could make a significant impact on the decision we make on the hydrocarbon industry, which is billions and trillions of dollars a year.

So I think spending money on that type of research, as Dr. Reiff has suggested, could be extremely valuable and something we probably do not pay enough attention to because it fits into the wrong pigeonholes in the budget.

Mr. PERKINS. Doctor, I have the largest coal-producing district in the United States, so I have a great interest in what you are talking about. [Laughter.]

Mr. TANNER. I thank the Chair.

Mr. NELSON. Well, we appreciate it very much.

I apologize for being late, but thanks to Congressman Volkmer that he started it out. I had the unpleasant task of attending a funeral of one of our former colleagues in Florida just today just before noon.

You all have been most enlightening. The committee has certainly enjoyed it, as you can see by the participation, and we appreciate it very much.

The meeting is adjourned.

[Whereupon, at 4:06 p.m., the subcommittee recessed, to reconvene at the call of the Chair.]

1990 NASA AUTHORIZATION

WEDNESDAY, APRIL 5, 1989

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Space, Science, and Applications,
Washington, DC.

The subcommittee met at 1:30 p.m., in room 2325, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Present: Representatives Nelson, Mineta, Schiff, Torricelli, Buechner, Packard, Smith of Texas, Rohrabacher, Skaggs, Schneider, Morella, and Perkins.

Mr. Nelson (presiding). Well, we are delighted to welcome three of our dear friends to this Committee that has given us guidance and counsel along the way over the years, so it's a homecoming for all of you. And we continue to look to your guidance and counsel.

There's something for having repetition for it to sink in, Dr. Paine, of you having been the visionary leader of the Commission on Space and a course that produced this very visionary document that, unfortunately, did not get the attention that it should have because of an extremely unfortunate set of timing circumstances, because it was right when this came out that Challenger exploded. And, of course, the nation's attention was turned to the tragedy.

And over and over, we keep bringing up this document. And, Dr. Tom Paine, who is a former Administrator of NASA, was the Chairman of that National Commission on Space that produced this report, and of which Executive Director is here, Marsha Smith.

And then, Mr. Chairman, it's just delightful to welcome you. It's a little bit different to look out there and see you out there. And that is a different view. I must remember that while you were down there in the big Committee room chairing and you had the 61(c) crew here, and I had the privilege of going out there and sitting with those guys looking back, and it's a whole different view. And this dias is kind of raised, isn't it? [Laughter.]

Especially over in that other Committee room, 2318. So we are delighted to have you back, and welcome home. And, again, we might give tribute where tribute is due. It's to Don Fuqua, who then, as Chairman of the Science and Technology Committee, and the excellent suggestions of his wife, Nancy, that they redecorated this room so that it could represent in photographs the nation's Space Program.

And you did an excellent, excellent job.

And, Charlie Walker, three-time astronaut, visionary, man on the cutting edge of commercialization in Space, a tireless worker and now back on terra firma as he puts together through an organization known as Space Cause the articulation of the need for a visionary Space Program.

And now a new title, the President of the National Space Society.

So we are delighted to have you now. Here's the context. It's another tough budgetary year. We've got about 14 billion pounds of potatoes that we're trying to put into a $13.2 billion sack. And, yet, we need to spend, particularly on long-lead research and development activities so that this nation can have the visionary kind of Space Program that its people expect it to have.

And so we're looking forward to having you give us some direction. We'll insert in the record an opening prepared statement by Mr. Sensenbrenner, and let me just then turn to Dr. Paine, for your comments.

Mr. NELSON. Why don't we just ask the three of you to share your comments with us and then we want to get it opened up into a free-wheeling kind of thing. And your written testimony will be put in part of the record.

So, just share with us what's on your mind.

Mr. MINETA. Mr. Chairman, if I might beg your indulgence——

Mr. NELSON. Sure.

Mr. MINETA [continuing]. Just momentarily, before Dr. Paine gets started.

Unfortunately, I'm going to have to testify before the Appropriations Committee at 2 o'clock, and I'm going to have to leave. But I really want to join you in welcoming these three giants of the industry because we have looked to them in the past for their leadership, as they have so well exhibited.

And we look to you for counsel. Unfortunately, I'm going to have to leave, but we do have your prepared statements and we'll have a chance to take a look at it.

But if I might also take a moment just to introduce someone whose in the audience. The person who is in our office right now who is a Madeira High School intern, but she wants to be an astronaut. And so I'd like to introduce Sara White. Sara——

Mr. NELSON. Well, before you leave, you want to get to know this fellow because there are not a lot of folks that have gone into Space three times.

Dr. Paine.

STATEMENT OF DR. THOMAS O. PAINE, THOMAS PAINE ASSOCIATES, SANTA MONICA, CA

Dr. PAINE. Well, thank you, Mr. Chairman. Of course, you've been in Space yourself, so we have lots of experience here. And part of the experience is me. I was just cogitating as you were speaking. I believe I've been testifying before this Committee now for 21 years, which makes me of age. [Laughter.]

My testimony has always been pretty much along the same lines, so I've submitted something for the record and I'll be brief in my opening remarks.

The principal point that I would like to make, what's on my mind today, is what I perceive as a very badly needed long-range goal for NASA. I think we have two kinds of Space agencies we can run in this country. One of them is what I might call with all respect the Department of Commerce Space Agency, where we pay it every year to do Space work.

And the other one is a goal-oriented, mission-oriented, challenging type of Space Agency that has the university scientists in this country, that has the technologists in our industry right out on the cutting edge trying to do almost impossible things.

There are a lot of disadvantages to that kind of a Space Program. The Soviets this last week have demonstrated what happens when you mount a very bold mission. They've now lost every probe they've sent to Mars and they lost two in this last attempt to rendezvous with Phobos.

But I give them great respect, however, for making the attempt. They know how much they can do. They know they were trying to do a little more than they can do. And knowing the people in the Space Science Institute, which you and I have visited together, Mr. Chairman, there's no question they will come back and they will mount another mission, until they succeed.

I think that from our own standpoint, as I see the discussion about the necessity for long-range goals going on now for some years, it's our National Space Report, which you requested because you weren't satisfied that NASA had sufficiently challenging goals. I have a feeling of dissatisfaction.

Twenty-one—twenty—years ago, when I appeared before this Committee, we had people going to the Moon. Today, we're having a big debate about the Space Station project and how we're going to fund it, and how many years it's going to take.

No one suggests we can do it anywhere near as quickly as we went to the Moon in the 1960s with the much more primitive technology of those days.

So I have a feeling of dissatisfaction and it really comes back to the question of leadership. And I would just like to conclude with several points which all of you recognize, but points which underscore the advantages of having long-range goals before our Space Agency.

It gives the NASA/industry/university team a high motivation and a common sense of direction and purpose that is bound to result in better management by not having stops and starts from confusion, and we get much more Space research for our money.

It allows the private sector to get more heavily involved when they know where the Space Program is going. It attracts overseas the partnerships and contributions from Japan, Europe and other countries.

It allows us to have a much better oversight of NASA. Once you know what it is that you're asking NASA to do and they've put down the milestones, they've proposed the budgets, they've organized to get the technology base built, you can, I think, provide much sounder oversight.

It encourages technological innovation. Once you see where the real tough points in returning to the Moon, opening a base, moving a thousand times farther out to Mars, learning how to utilize the resources of the Red Planet so we can live off the land, all kinds of innovative ideas then begin to come out—how you can get over those stumbling blocks.

That's the thing that puts the United States right out on the cutting edge of technology. That's why the United States today has its tremendous lead in aerospace technology in industry, making it our largest export item.

So, for all of those reasons, I think that we definitely need long-range goals and I think with a new Administration coming in, it is time to put pressure on to get those. We really need Presidential leadership here, and that is my message today.

Now, I know everybody always points to the advantages. Let me just point out the disadvantage. The disadvantage of setting long-range goals for NASA is that it requires leadership, and leadership is tough.

But I submit to you that that's really what we're all about here in the nation's capital and it's high time that we got on with the business of giving NASA a much better high-level purpose and sense of direction.

And, with that, I'll pass to my respected colleague here.

[The prepared statement of Dr. Paine follows:]

URGENTLY NEEDED: NEW GOALS FOR NASA

Dr. Thomas O. Paine
Administrator - NASA, 1968-70
Chairman - National Commission on Space, 1985-86

Testimony before the Subcommittee on Space Science and Applications
U.S. House of Representatives, Washington, D.C.
April 5, 1989.

NASA is a mission-oriented agency in desperate need of a challenging mission. In pursuit of exciting goals NASA has flourished; without long-range objectives it has languished. Our space program reflects the wisdom of *Proverbs* 29:18 "Where there is no vision, the people perish." Presidential leadership is essential to set inspiring goals beyond Earth orbit that will reinvigorate NASA and lift human spirits around the world.

High-level direction, not money, is our space program's most critical need. In 1988 dollars, NASA's budgets in the decade of the 1970s totalled $88 billion, and in the decade of the 1980s $93 billion. If present trends continue, space budgets in the 1990s will total $150 billion, a sum that would pay for two Apollo programs. But without bold long-range goals, NASA's achievements will fall far short of its potential.

Twenty years ago the first humans voyaged 240,000 miles from Earth to orbit the Moon. They sent back close-up views of rugged lunar peaks and craters, and far-out views of our breathtakingly beautiful blue planet. During nine Apollo expeditions, a dozen astronauts landed on the Moon and established six base camps from which they explored the ancient lunar surface. Their footprints and jeep tracks record humanity's first evolutionary steps toward a multi-planet species.

NASA's 1969 triumph reflected President John F. Kennedy's vision and vigor. He understood leadership. He saw clearly that he must set a challenging long-range goal for NASA if America was to achieve preeminence on the new frontier. Rejecting a space station as too easy, and a mission to Mars as too difficult, he resolved to send U.S. astronauts to the Moon. Although the first American had not yet flown in orbit, a cheering joint session of Congress approved his bold enterprise.

The stirring prospect of Earthlings exploring the Moon stimulated the greatest government-industry-university teamwork since World War II. This bold objective gave NASA a clear direction, and generated sustained national support. Working toward this highly-visible goal allowed plans to be made, milestones laid out, budgets prepared, technologies developed, facilities created, systems built, crews trained, and progress measured. Eight years later, NASA's spectacular lunar landing -- on time and within budget -- was watched and applauded by the entire world. The lack of presidential leadership since Apollo, however, has sapped NASA's vigor. The twentieth anniversary of our historic lunar landing finds NASA marking time, awaiting a presidential decision on America's future in space.

The need for more effective executive direction has been apparent for years. In 1984, Congress created the National Commission on Space to look 20 years into the future and recommend long-range goals for America's civilian space program. The Commission's final report, *Pioneering the Space Frontier*, proposed to the President and the Congress in 1986 that America **"lead the exploration and development of the space frontier, advancing science, technology and enterprise, and building institutions and systems that make accessible vast new resources and support human settlements beyond Earth orbit, from the highlands of the Moon to the plains of Mars."**

The international acclaim that greeted the Commission's award-winning report made it clear that men and women of many nations would eagerly join America in this great high-technology adventure. The recommendations were clear: we should build a "Bridge between Worlds" and establish Lunar and Martian Bases. We should monitor from orbit the precious biosphere of our beautiful blue planet, accelerate robotic exploration of the Solar System, increase astrophysical research from orbiting observatories, and intensify the search for extraterrestrial intelligence. We should establish a network of bases throughout the Inner Solar System using advanced transportation and life-support technologies to facilitate economical travel beyond Earth and "living off the land" on distant worlds. In a 21st Century Age of Exploration these bases will evolve into self-sufficient communities on the cutting edge of humanity.

Appropriate long-range goals for NASA can therefore be simply stated: **to monitor our planet's fragile biosphere, to accelerate scientific research aimed at understanding the structure and evolution of the universe, to broaden the search for extraterrestrial intelligence, to reinvigorate Solar System exploration, and to create an effective network of space transportation systems and bases throughout the Inner Solar System to sustain human operations on the Moon and Mars.** Five critical program elements will be involved:

1. A **Highway to Space** that provides reliable, low-cost access to Earth orbit for passengers and cargo;

2. An **Orbital Spaceport** that supports spacecraft assembly, servicing, and refueling for robotic and piloted near-Earth and deep-space operations;

3. A **Bridge between Worlds** that furnishes practical transport to the Moon, and extends human spaceflight a thousand times the lunar distance to Mars, for the delivery of automated power stations, habitats, laboratories, production shops, processing facilities, and crews and cargo;

4. **Extraterrestrial Prospecting & Processing** that establishes the location, character and techniques required to develop Lunar and Martian resources; and

5. **Closed-Ecology Biospheres** that enable pioneers to utilize indigenous resources to "live off the land" and become self-sufficient on other worlds.

Each of these five elements is challenging, and each requires technology advances across a broad front, from high-temperature materials and supercomputers to molecular engineering and artificial intelligence. Yet we know far more today about establishing evolutionary outposts on other worlds than we knew about the lunar surface when President Kennedy set America's sights on the Moon in 1961. What is required are clear goals, purposeful programs to create the required technology base, and sustained support. Let's review progress in each of the critical fields.

1. The Highway to Space

Our most urgent need is a significant reduction in the cost of transporting cargo and crews between Earth and Low Earth Orbit. In the first 30 years of the Space Age we've launched spacecraft from every continent and the Moon, with cargoes ranging in size from a few pounds to more than 100 tons. Now we must significantly reduce the cost and hazards of space transportation.

The U.S. Space Shuttle pioneered high-pressure hydrogen-oxygen engines, lightweight materials, high-temperature reentry tiles, automated landing systems, flight through the range of mach numbers from zero to twenty five, vehicle reusability, payload return to Earth, and many other significant innovations. It is a superb craft for carrying half a dozen astronauts and substantial payloads up and down from orbit in infrequent missions lasting several weeks. The objective of routine low-cost transport cannot be achieved by this experimental piloted vehicle, however, and shuttle operations are too expensive to continue indefinitely. The shuttle has taught us much about the system requirements for routine access to orbit, but economical space transport remains one of NASA's highest-priority objectives.

Although commercial launch services are available from many nations, most employ labor-intensive, one-shot missile technologies from the 1960s, with inherent high cost and single-point failure modes. Launch vehicles today are about where aircraft were when the Red Baron flew with canvas and piano wire. But we can envision a future space DC-3, and the required technology base is under development in the Civil Space Technology Initiative (CSTI) program and the National Aero-Space Plane (NASP) project.

The X-30 National Aero-Space Plane, sometimes called the *Orient Express*, represents a new approach to low-cost passenger flight to orbit. British and German aerospace engineers are studying similar designs. The X-30 is a piloted flight demonstration vehicle being developed with supercomputers to integrate the vehicle's aerodynamic shape and air-breathing propulsion systems over a wide range of flight parameters. The aim is a single-stage-to-orbit space transportation system capable of horizontal takeoff and landing from conventional airfields. This ambitious program is advancing a host of aerospace technologies broadly applicable to future economical launch systems as well as to military and civil aircraft.

The U.S. Air Force and NASA are also jointly studying alternative approaches to next-generation, heavy-lift, non-piloted launch vehicles that promise major reductions in the cost per pound of cargo delivered to orbit. This will favorably impact everything we do in space - but until NASA is given clearer high-level direction and goals, the characteristics of future payloads and resulting launch system requirements cannot be specified. Serial production of fully-automated, next-generation launch vehicles is essential to reduce significantly the risk and cost of orbital operations.

2. Orbital Spaceport

America's *Skylab* demonstrated the practicality and utility of a manned orbital station. Earth observations, solar X-ray astrophysics, studies of the physiological effects of months of prolonged weightlessness, ultraviolet astronomy, and many other experiments were conducted with great success. Soviet cosmonauts in long flights aboard their *Salyut* and *Mir* space stations have conducted medical, biological, materials, earth observation, astrophysical, and a host of other scientific experiments. They have demonstrated exposure to zero gravity sufficient for a one-year piloted flight to Mars. NASA has now started work on Space Station *Freedom* in partnership with European, Canadian and Japanese space agencies.

This space station should lead to a next-generation Orbital Spaceport combining the functions of transportation node, habitat and workplace, spacecraft assembly and checkout center, satellite and vehicle maintenance base, supply depot, and fuel farm. New concepts may be included, like ultra-strong space tethers tens of miles in length. This "Cape Kennedy in Orbit" will support a diverse fleet of satellite platforms in low Earth orbit, and despatch and recover spacecraft for robotic and human flights to geosynchronous orbit, the Moon, Mars, and other destinations throughout the Solar System.

3. The Bridge Between Worlds

Modular hydrogen-oxygen engines with aerobraking shields can be developed for Earth-Moon and Earth-Mars cargo and passenger flights. Lower cost cargo transport is in prospect using low-thrust, high-specific-impulse solar or nuclear electric propulsion systems; these are also promising for high-energy missions beyond the asteroid belt. Other potential new technologies include mass drivers, tether systems, rail guns, nuclear fission drives, solar sails and laser beam propulsion.

Large cycling spaceships swinging permanently between the orbits of Earth and Mars appear promising for routine passenger transport between worlds in the 21st Century. Space taxis from Orbital Spaceports at each end would obviate the need to accelerate and decelerate the massive cycling transports, so they can be well-equipped, sturdy, and heavily shielded from radiation. Amenities like scientific laboratories, artificial gravity, and 24-hour food production can be provided. Intensive development of the technology base for interplanetary transport also awaits a presidential decision on America's long-range goals in space.

The 21st Century "Bridge between Worlds" will provide safer and more convenient travel between Earth and Mars than the wooden sailing ships which linked America to the Old World in the 18th Century, or the ox-drawn prairie schooners which opened the western frontier. Travel times around the Inner Solar System will be comparable.

4. Prospecting and Process Development

Lunar orbiters and automated and piloted surface vehicles have taught us much about the Moon's resources, but we've literally only scratched the surface. We know that finely-ground minerals containing metals, glasses and oxygen are abundant, and that terrestrial plants thrive in mineral-rich lunar soils. The scarcity of hydrogen and other light elements on the Moon may make it less promising than Mars for self-sufficient settlements in the long run, since water will probably have to be imported. The cold lunar polar regions might contain volatile materials, however, and should be explored at an early date. The Moon's proximity to Earth allows inexpensive teleoperations, which are difficult on Mars due to the long communication time delays across tens of million of miles.

Should the Moon or Mars be the focus of future space operations? This is like asking whether you should buy a car to go to work or to go on vacation; when you own it you'll do both. A broad space technology base, transportation infrastructure, and network of bases beyond Earth orbit will support both Lunar and Martian operations, as well as wide-ranging robotic ventures throughout the Solar System.

NASA's Mariner and Viking interplanetary spacecraft have provided a preliminary assessment of the magnificent terrain and rich resources of Mars, including extensive data on the planet's harsh climate. In 1992, NASA plans to launch a Mars Observer satellite into polar orbit around the red planet to obtain detailed geological data on its surface topography and mineral resources. Although the Soviets have had bad luck with their Mars missions, they plan to land an automated roving vehicle in the 1990s to transmit geological information back to earth-bound scientists. JPL has similar studies under way. The proposed Soviet robotic geology mission includes a balloon designed to soar above the Martian landscape in sunlight, and descend at night to sample the surface with a trailing "snake". Soviet and American scientists are anxious to return core samples from Mars as soon as possible to initiate resource analysis and utilization studies on Earth. This critical next step has been proposed as a prime candidate for a cooperative international mission.

Data from the Mariner and Viking programs show that every element required to support life is present on Mars, but no life has been detected. Primitive life or fossils remain a possibility, however, so all Martian landers are sterilized to preserve the pristine environment. The thin carbon dioxide atmosphere of Mars contains water vapor which forms frost during the cold nights, so oxygen and water are available. Water is also present as ice at the poles, and probably exists as underground permafrost.

Automated processing facilities and closed-ecology life support systems will make possible self-sustaining human communities on Mars. 21st Century Martians will require economical interplanetary transport and highly automated production facilities, but these appear attainable with future technology. The reward is access to the magnificent terrain of Mars and its vast untapped resources. The settlement of Mars will double the land area available to humanity.

5. Closed-Ecology Biospheres

Air, water and nourishing food must be recycled within automated, closed-cycle life-support systems to minimize the costly transport of supplies from Earth. Air and water have been successfully regenerated in prototype systems, and the problems are reasonably well understood. Little is known, however, about constructing artificial biospheres capable of food recycling. The Earth's solar-powered biosphere is 24,000 miles in circumference and, except for the impact of a few large objects from space, has operated reliably for four billion years. Now we must learn how to compress our complex food chain into compact recycling conservatories capable of operating on the Moon and Mars. It will be easy to fit in the plankton, but where will we exercise the whales?

Fortunately, rapid progress in the biological sciences and genetic engineering provides a host of new techniques to help overcome the complexities of closed-ecology systems. A number of experimental projects are underway in the United States and the Soviet Union, including the ambitious *Biosphere II* project near Tucson. Of all the critical elements, this remains the least understood and most challenging. Because of the long time scale involved and the great potential benefits from such research, this field should receive high priority.

Arid areas of Earth, like the American Southwest, the Middle East, and Central Australia, are potential beneficiaries of space biosphere research. Where water is insufficient to support irrigation, a breakthrough in closed-ecology food production utilizing water recycling could have enormous impact. This is but one of the many potential benefits to be derived from space research. Artificial intelligence, high-productivity robotic systems, ultra-high-strength materials for space tethers, advances in aerospace medicine . . . . . the broad technology base needed to support operations on the Moon and Mars will find widespread applications on Earth. As Europeans gained from the development of the Americas and Australia, Earthlings will derive many benefits from pioneering the limitless frontiers of space.

CONCLUSIONS

Our advancing technology base has initiated a new Age of Exploration that has already brought substantial benefits to Earth, and in the 21st Century will open the Moon and Mars for pioneering human settlement. Developing the space frontier will contribute to scientific knowledge, productivity gains, economic growth, education, medicine, agriculture, international partnerships, and many other features of terrestrial life. Scientific progress interacting with the vastness of the Space Frontier can eliminate Malthusian limits to human aspirations as the human intellect expands terrestrial life throughout the Solar System. Space exploration now offers another advantage: in an era of arms reduction, beating terrestrial swords into extraterrestrial plowshares allows the United States to maintain a national reserve of valuable aerospace capability.

All of the peoples of our home planet should participate in the upward and outward evolution of terrestrial life, but America should lead the way. Our citizens look to the President and the Congress to set inspiring goals for NASA that will maintain U.S. technical preeminence. America should lead the new Age of Exploration because of our magnificent heritage from Columbus, our lively frontier tradition, our rich gene pool, our magnificent science and engineering, and our exponentially-growing five trillion dollar economy. Our people know how to "live off the land" by taming hostile environments, and how to create lively new societies remote from the Old World.

I believe that this is America's destiny. The drive to extend life beyond Earth represents the next step in the evolution of our species. This great adventure will inspire and challenge our young people, give us a new insight into the role of intelligence in the cosmos, and open the way for our descendants in another century to reach the stars.

Reference: *Pioneering the Space Frontier - Final Report of the National Commission on Space*, Bantam Books, New York 1986.

Tom Paine

Mr. **Nelson**. Chairman Fuqua.

STATEMENT OF THE HONORABLE DON FUQUA, FORMER CHAIRMAN OF THE FULL COMMITTEE, PRESIDENT, AEROSPACE INDUSTRIES ASSOCIATION, WASHINGTON, DC

Mr. **Fuqua**. Thank you very much, Mr. Chairman, and members of the Subcommittee. I'm very honored to be asked to participate. As the President of the Aerospace Industries Association of America, commonly known as AIA, we are a trade association representing the major U.S. aerospace companies that are engaged in research, development and manufacture of aircraft, missiles, space systems and related propulsion guidance and control and other equipment.

And we're very delighted to support the NASA Authorization Bill for Fiscal Year 1990.

In drafting the National Aeronautics and Space Act of 1958, the Congress charged NASA with the preservation of U.S. leadership in Science and Technology. And over the past three decades, I think NASA's response to that directive has been nothing but magnificent. Over the last 30 years, NASA, under the able leadership of many people, including Tom Paine, spear-headed a space science program that has generated more knowledge about Earth and the Universe than man had acquired in all the prior years of history.

And at the time when our planet is more threatened than at any time by man's tenancy, the importance of NASA's space science cannot be over-emphasized. Only can a Space global phenomenon such as the greenhouse effect be thoroughly understood except from Space.

Our aeronautical programs have led to us being a preeminent player in that in basically every air-faring nation in the world.

But, all of these programs and machines of extraordinary performance and capability that we have today are put about in the great advances that we have made, have brought us the envy of the world. People did all of these things. People are such an important part of it. They conceived, they planned the complex machines that make these dramatic accomplishments possible. And the underlying strength of the U.S. aerospace program is human imagination, skill and dedication to the task.

And knowledge is the principal product of NASA. All the wondrous machines and impressive technology that excite and mystify scientists and future generations, however significant and far-reaching changes in age, race, sex and educational background of the next generation of American workers is not enough being done to bridge the gap between the current output of our education system and the requirements for the future.

And industry and NASA need to work harder to capitalize upon our role as the prime motivators in this new generation.

Keeping those thoughts in mind, Mr. Chairman, I'd like to offer a thought or two on the general subject of what type of Space Program the U.S. should pursue.

I'll offer no recommendations for specific long-range goals, whether the program should focus on a lunar base or manned mission to Mars. Such decisions are infinitely more complicated than they appear, and they should be left with those charged with the development of such a strategic plan.

But I would like to offer broad technological goals that comprise philosophy of investment. The philosophy transcends individual programs and missions. It involves a recommitment of what we refer to as the Spirit of Apollo.

I can't sum it up—or I can sum it up in this way, that:

We should pursue a program that will assure continued U.S. space leadership.

Now, the quest for Space leadership is an investment in the nation's future. The advancement that it generates brings corollary advantages such as new industries, new jobs, new products. And our current research and development capabilities in aerospace are a major national asset, affecting not only our future leadership role in aeronautics and space, but also in the long term strategic and economic position of the country.

And while polls indicate that Americans put space high on their list of national priorities, it's time for the Congress, the Administration, NASA and industry to ensure that the Americans better understand exactly why it should be high on their list of priorities.

AIA is making an effort to communicate that message, that:

space is an investment in tomorrow.

And at the same time, we are attempting to broaden the Space constituency by attracting those of a pragmatic turn of mind who seek evidence of a practical return of Space outlays. And there is, in our view at AIA, a practical return for every significant order of accelerated development of advanced technology.

We have recently established a National Center for Advanced Technology, which will serve as an information center for government, industry and academia. And it will be a premier repository, linking those who conduct state of the art research and eight key technologies that we have identified as having the highest leverage, potential payoff and the broadest application.

And I'd like to just enumerate those:

Composite materials, very large-scale integrated circuits, software development, propulsion systems, advanced sensors, optical information processing, artificial intelligence and ultra-reliable electronics that we think are very vital to this country's competitiveness, not only in space, but also in the Defense and the commercial sector.

So, when I say we need a program that will ensure continued space leadership, I mean a program sufficiently challenging to demand high levels of technology development and sufficiently comprehensive to bring scientific gain to a wide spectrum.

The continuation of a manned space program is a critical element of the success of this agenda. While unmanned space probes, provide important information that is expandable to our understanding of our Solar System and the Universe at a very low cost, the technology required of such missions is of sufficiently lower order of that needed to put a man in the Loop.

Unmanned Spacecraft also do not accomplish one of the basic goals of American experience in Space exploration; since our first venture into Space 31 years ago, the underlying goal has been human exploration of celestial bodies beyond Earth. And one cannot discount the incredible emotional impact of a man in Space, whether it's motivating today's scientists into the next great discovery or challenging some youngster's interest in math and science, or making us aware of the fragility of both human existence and the planet that we live on, the Space Program offers us all.

So there's an ever-increasing monetary cost associated with the great technology advances. The NASA first budget in 1958 was less than $90 million. The outlays peak in 1966 at the Apollo time was less than $6 billion.

So, with this year's budget at more than $13 billion, a part of this can be explained in terms of inflation, but a greater degree is due to what we call the cost of progress factor.

Each time we reach a new level of Space achievement, the next level becomes a little more difficult to obtain in terms of technology. And we have reached a level where the steps contemplated for the 21st century will strain the limits of human capability and will, therefore, be incredibly expensive.

And I think it's safe to say that a lunar based or manned Mars exploration will make current budget look kind of paltry as compared to the numbers of Apollo.

But, in order to attain those lofty goals, we must look for innovative ways to achieve major reductions in space cost without sacrificing the knowledge that results from man's involvement in the process.

In an area that offers particular promise for savings is the development of advanced launch vehicles. That offers significantly lower costs of delivering payloads into orbit.

Lowering the cost per pound payload to one-tenth of its current cost is a reasonable goal for the 21st century.

Reducing manufacturing costs can also have a substantial effect on future space program affordability. Both government and industry will have a turn to think affordability. Learn to think affordability from the program concept to design to fabrication to systems operation.

If we do not, we may price ourselves out of the international space competition.

And Congress needs the evidence of real commitment to assist in long-term planning for Space Program; passing multi-year funding bills is an initial step to create the stability and confidence that allow economic allocation of resources.

And I applaud the leadership of this Subcommittee and the full Committee, who have demonstrated your leadership in this area.

And even those accomplishments may not be enough to achieve the higher-priced, higher technical goals and vision for the 21st century. And the U.S. should not summarily dismiss out of hand space projects of other nations, including the Soviet Union.

In order to accomplish such missions, we may have to rely on international agreement, such as we're doing now with Space Station.

This industry currently conducts many of its operations, including defense production and commercial transport manufacturing on an international basis, and is well aware of the difficulties of technology transfer, the balancing of national responsibilities and the funding requirement standardizations, and so forth.

But, experience has shown, however, that the disadvantages are far more offset by the advantages of spreading costs, a greater likelihood of success when the program is structured to take advantage of each participant's special capabilities and the potential for an improved trade and political environment on Earth through relationships strengthened in Space.

Mr. NELSON. We're going to have to go vote.

Mr. FUQUA. All right, sir.

Mr. NELSON. You've only been gone two years and you've forgotten what the bells mean. [Laughter.]

Mr. FUQUA. I knew it was 2 o'clock and it was about time to approve the—[Laughter.]

Mr. NELSON. We already passed the second bell, so we're down to about eight minutes. So we're going to have to roll.

The Committee will stand in recess.

Mr. NELSON. Good afternoon, and welcome again.

Mr. Fuqua, we got you in mid-sentence.

Mr. FUQUA. Mr. Chairman, if I can just summarize, I think that even on a collaborative basis, we're talking about the joint projects, and so forth, with other people, that great advances that are being considered are going to be very costly.

But I learned a long time ago as a member of this Subcommittee and others that I think some of the federal outlays are expenditures and others are investment opportunities that will ultimately pay off economically, socially and political dividends to the country.

And each year we have before us the NASA authorization and it is an opportunity to make such investment. And from possibly no other budget outlay do we see such immense and varied payoffs. And the Administration has provided a very generous blueprint of $13.3 billion for FY 1990, and I'm sure that this Subcommittee and the Full Committee can recommend it to their members to the House as a wise investment.

[The prepared statement of Mr. Fuqua follows:]

TESTIMONY OF DON FUQUA
AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.
CONCERNING THE
FY '90 NASA AUTHORIZATION

APPEARING BEFORE
THE SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
U. S. HOUSE OF REPRESENTATIVES

April 4, 1989

Mr. Chairman and Members of the Subcommittee:

I am Don Fuqua, President of the Aerospace Industries Association of America, Inc. (AIA), the trade association representing the major U.S. aerospace companies engaged the research, development and manufacture of aircraft, missiles and space systems and related propulsion, guidance, control and other equipment. AIA appreciates the opportunity to testify before the Subcommittee on the NASA Authorization for fiscal year 1990.

In drafting the National Aeronautics and Space Act of 1958, the Congress charged NASA with "the preservation of U.S. leadership in science and technology". Over the last three decades, NASA's response to that directive has been nothing short of magnificent.

Over the last 30 years NASA has spearheaded a space science program that has generated more knowledge about Earth, the near Earth environment, and the universe than man had acquired in all the prior years of history. At a time when the Earth is more threatened than ever by man's tenancy, the importance of NASA's space science component cannot be overemphasized. Only from space can global phenomena such as "the Greenhouse effect" be thoroughly understood.

This year and 1990 will be banner years for space science, with the launch of several long awaited missions: the Hubble Space Telescope, the Magellan mission to Venus, the Galileo mission to Jupiter and others. It is necessary to look beyond these launches and fund missions for the future, such as CRAF and CASSINI which will study the basic building blocks of both our solar system and life itself.

NASA's program of aeronautical research has produced a lengthy list of technological advances that have contributed significantly to U.S. development of superior military aircraft and commercial transports serving the airlines of virtually every airfaring nation.

All of these programs involved machines of extraordinary performance and capability. But as we look to the future, we must remember that machines did not accomplish the great advances in science and technology that have made U.S. aerospace the envy of the world. People did. People conceived and planned the exquisitely complex machines that made the dramatic accomplishments possible. People designed them, built them, tested them and operated them. The underlying strength of the U.S. aerospace program is human imagination, skill, and dedication to the task.

Knowledge is the principal product of NASA. All the wondrous — machines and impressive technology excite and mystify scientists and future generations. However, significant and far reaching changes are occurring in the age, race, sex and educational background of the next generation of American workers and not enough is being done to bridge the gap between the current output of our education system and the requirements of the future. Industry and NASA must reinstill a desire to overcome complex problems, to be in love with the future, and to provide a vision of future horizons to conquer. We need to work harder to capitalize upon our roles as the prime motivators of this new, different generation. It can be an exciting time full of promise if we capitalize upon the unique skills they bring to science and engineering.

Keeping these thoughts in mind, I would like to offer a thought or two on the general subject of what type of space program the U.S. ought to pursue. I can sum it up this way: we should pursue a program that will assure continued U.S. space leadership.

I say continued because I do not subscribe to the oft-repeated assertion that that we have already lost space leadership. Temporary loss of launch capability following the Challenger tragedy does not translate directly into lost leadership.

To be sure, we have lost some momentum. There are specific areas of space technology -- civil remote sensing and microgravity research where we can no longer claim leadership. This is not so much because we are dragging our feet but because other nations have been more cognizant of the opportunities and have targeted specific areas of space potential for special attention.

In overall space capability, the U.S. still leads: the scientific base, the technology we have developed, the facilities we have built, the personnel expertise in government and industry all that is still in place.

It is important to regain the perception of leadership that was lost during the 32-month hiatus during which we were unable to demonstrate our capability. It is important to maintain a clear leadership role into the 21st Century.

Space leadership involves much more than a nation's prestige within the international community; the real gains are less visible but more concrete.

Acknowledged space leadership symbolizes a nation's superior scientific and technological capability in space as well as in many other areas of productive endeavor. Meeting the goals of challenging space programs drives advancements across a broad spectrum of scientific and technological disciplines.

The quest for space leadership, therefore, is an investment in the nation's future, because the advancements it generates bring corollary advantage in other areas of national importance such as new industries, new jobs, and new products. Our research and development capabilities in aerospace are a major national asset, affecting not only our future leadership role in aeronautics and space, but also the long term strategic and economic position of this country.

While polls indicate that Americans put space high on their list of national priorities, it is time for the U. S. Congress, the Administration, NASA and industry to ensure that Americans understand exactly why it should be high on their list of priorities. We in the AIA are making an effort to communicate the message that space is an investment in tomorrow. At the same time we are attempting to broaden the space constituency by attracting those of a pragmatic turn of mind who seek evidence of a practical return on space outlays. There is, in AIA's view, a practical return of very significant order in accelerated development of advanced technology.

AIA has recently established the National Center for Advanced Technologies (NCAT) which will serve as an information center for government, industry, and academia. It will be the premier repository linking those who conduct state of the art research in eight key technologies identified by AIA as needing immediate and special attention based on selection criteria of highest leverage, potential payoff and broadest application. These areas: composite materials; very large scale integrated circuits; software development; propulsion systems; advanced sensors; optical information processing; artificial intelligence~~;~~ and ultrareliable electronics are vital to this country's competitiveness not only in space, but also in the defense and commercial sectors.

So when I say we need a program that will assure continued space leadership, I mean a program sufficiently challenging to demand high levels of technology development, sufficiently broad to require advances in many areas of technology, and sufficiently comprehensive to bring scientific gain across a wide spectrum. It is only with these challenges that Americans will continue to enjoy the high standard of living that results from being a technology leader.

The continuation of a manned space program is a critical element in the success of this agenda. While unmanned space probes provide important information that has expanded our understanding of our solar system and the universe at a very reasonable cost, for obvious reasons the technology required of such missions is of a significantly lower order than that needed to put man in the loop.

Not only do unmanned spacecraft require less innovative, leading edge technology, they also do not accomplish one of the basic goals of the American experience in space exploration. Since our first venture into space 31 years ago, the underlying goal has been human exploration of celestial bodies beyond Earth. The space policy enunciated by the Reagan administration and reaffirmed by President Bush envisions human activities beyond Earth's orbit. Any suggestion that we forego such advances in favor of a less costly robotic space program amounts to a proposal that we abdicate space leadership and its attendant benefits once and for all.

One cannot discount the incredible emotional impact man in space has. Whether it is motivating today's scientists onto the next great discovery, piquing a youngster's interest in math and science, or making us aware of the fragility of both human existence and the planet we live on, the space program affects us all. This was underscored in a recent poll by HART Research Associates examining the attitudes of Americans ages 18-44. The respondents were asked to name two or three events of the past two decades with the greatest personal impact on their lives. These three were at the top: the explosion of the Challenger, the Vietnam War and the AIDs epidemic. Since this is the group that will make up the majority of voters for the next 20 years, these are the premier forces that will guide this country's political decisionmaking. The decision we make now, to commit our resources to a continued manned presence in space and further human exploration of the universe, will give this group a positive context for the Challenger accident. It will be seen as a costly, but necessary step, rather than a tragic symbol of a challenge we chose to avoid.

In addition to the human cost that can be associated with great technological advances, there are ever increasing monetary costs. NASA's first budget in 1958 was less than $90 million. Outlays in the peak Apollo year 1966 amounted to less than $6 billion. This year's budget request is more than $13 billion, with the space station alone accounting for $2.05 billion. Part of this can be explained in terms of inflation, but a greater degree of the rise is due to the "cost of progress factor".

Each time we reach a new level of space accomplishment, the next level becomes more difficult to attain in terms of technology. We have reached a level where the next steps contemplated for the 21st Century will strain at the limits of human capability and will therefore be incredibly expensive.

I cannot offer dollar numbers for such missions as the lunar base or manned Mars exploration, but I think it is safe to say they will make the shuttle and the station look as paltry as the numbers from the days of Apollo do now.

In order to attain these goals, then, we must look for innovative ways to effect major reductions in space costs without sacrificing the knowledge that results from man's involvement in the process.

An area that offers particular promise for big savings is development of advanced launch vehicles that offer significantly lower costs of delivering payloads to orbit. I think that lowering the cost per pound of payload to one-tenth its current cost is a reasonable goal for the 21st Century.

Launch and mission operations costs constitute a sizable portion of the expense of placing payloads into orbit. The technologies that would be required to reduce the recurring costs of ground and mission operations either exist today or are currently under development. Reducing manufacturing costs is another measure that can have a substantial effect on future space program affordability. We, both government and industry, must go well beyond that. We will have to learn to "think affordability" from program concept to design to fabrication to system operation. If we do not, we may price ourselves out of the international space competition.

Congress needs to evidence a long-term stable commitment to assist in long-term planning of space programs. Passing multi-year funding bills is an initial step to create the stability and confidence that allow economic allocation of resources by industry. I applaud the leadership this Subcommittee and the full Committee have demonstrated in this area.

Even these accomplishments may not be enough to achieve the high priced, high tech goals envisioned for the 21st Century and the U.S. should not summarily dismiss out of hand major space projects with the Soviet Union, including a joint manned mission to Mars. Such giant steps will in all probability prove beyond the funding capability of any single nation, including the two superpowers. In ten years the international collaboration agreement currently being assembled for the space station may well be the norm, as it currently is in defense production and commercial transport manufacture.

This industry is well aware of the difficulties in conducting large, multi-year programs on an international basis: technology transfer, conflicting national policies, managerial differences, the balancing of national responsibilities and funding requirements, standardization, and so on.

However, experience has shown that the disadvantages are more than offset by the advantages of spreading costs; a greater likelihood of success when the program is structured to take best advantage of each participant's special capabilities;, and the potential for an improved trade and political environment on earth through relationships strengthened in space.

Even on a collaborative basis the great advances being considered will be costly. But I learned during my years as a member of this subcommittee and others, to think of some federal outlays as expenditures and others as investment opportunities that would ultimately pay economic, social, or political dividends to the nation.

Each year we have before us in the NASA authorization the opportunity to make such investments. From possibly no other budget outlay do we see such immense and varied payoffs. The Administration has provided a generous blueprint of $13.3 billion for fiscal year 1990, I am sure this subcommittee can recommend it as a wise investment.

Aerospace
Industries
Association

DON FUQUA

Don Fuqua is President and General Manager of the Aerospace Industries Association of America, Inc. (AIA). He assumed the position on January 1, 1987, and serves as a leading spokesman for the U.S. aerospace industry.

Mr. Fuqua is a member of the AIA Board of Governors and oversees the activities of 10 AIA councils, services and offices that serve the Association's membership.

Before joining AIA, Mr. Fuqua served 12 terms as a U.S. Congressman, representing Florida's Second Congressional District. He was elected Chairman of the House Science and Technology Committee in 1979, after serving on the Committee since joining Congress in 1963. He gained firsthand knowledge of the U.S. space program as a member of the subcommittee overseeing the program in its formative years and as Chairman of the Subcommittee on Space Science and Applications from 1971 to 1981.

Mr. Fuqua also served as chairman of the Science and Technology Committee's Subcommittee on Energy Development and Applications and as ranking majority member of the House Committee on Government Operations.

As Chairman of the Science and Technology Committee, Mr. Fuqua personally inspected and reviewed research projects throughout the nation. He delved into fields as far ranging as the development of competitive aircraft of the future, the application of space technology to the needs of the elderly and disabled, the design of more fuel-efficient autos, the development of liquefied coal, and the protection of the environment from hazards as common as water weeds and as advanced as nuclear waste. The Committee has direct authorization and oversight responsibility for most of the nation's government-funded civilian research, development and demonstration programs.

Prior to his election to Congress, Mr. Fuqua served from 1958 – 62 as an elected member of the Florida House of Representatives from Calhoun County.

Mr. Fuqua was born in Jacksonville, Florida in 1933. He received a B.S. degree in agricultural economics in 1957 from the University of Florida. He served in the U.S. Army from 1953-55, during the Korean conflict.

Mr. Fuqua has received numerous awards, including the National Aeronautics and Space Administration Distinguished Public Service Medal, the National Science Foundation Distinguished Public Service Award and the Robert H. Goddard Memorial Trophy. He holds honorary degrees from the University of Notre Dame, Florida Institute of Technology, Florida State University and Florida A&M University. Mr. Fuqua has been named to the leadership honorary societies at Florida State University and the University of Florida and served as National President of the University of Florida Alumni Association in 1979.

As President of AIA, Mr. Fuqua is a member of the Council of Defense and Space Industry Associations (CODSIA) and the International Coordinating Council of Aerospace Industries Association.

Mr. Fuqua is an honorary member of the American Institute of Aeronautics and Astronautics and the National Aeronautic Association. He is on the Board of Governors of the National Space Club and the National Space Institute.

Mr. Fuqua belongs to numerous other community and service organizations, including the United States Capitol Historical Society, the Florida State Society, The Planetary Society and the National Aviation Hall of Fame.

Mr. NELSON. Thank you, Mr. Fuqua.
Mr. Walker.

STATEMENT OF CHARLES WALKER, PRESIDENT, NATIONAL SPACE SOCIETY, WASHINGTON, DC

Mr. WALKER. Thank you, Mr. Chairman. And I want to express my very sincere thanks for the invitation to the National Space Society to testify today. I am in this capacity President and Chairman of the Executive Committee of the National Space Society.

And I want to express to you, to the Subcommittee and to the Full Committee the hopes and dreams and aspirations of the National Space Society, particularly as they relate to your concerns about the NASA budget, the NASA authorization this year.

The Space Society that I am representing is a growing grassroots citizens organization. We have more than 25,000 members at this point in time. We have 125 active chapters, not only in this country but in six other nations around the world.

We're a family of organizations. And as you pointed out in your gracious introduction early on, I am not only President of the National Space Society, but I'm also Chairman of one of its sister organizations's grassroots lobbies, Space Cause.

We also have as part of the family a political action committee, Space PAC.

Space activists are determined to be heard in this country and for this country to, in fact, reflect their visions that they believe is, in fact, a vision of this nation, to see Space as a vital part of this nation's future.

That vision to us is, in fact, clear. That this nation needs to create a space-faring civilization which will establish communities beyond the Earth; promote the exploration and economic development of Space, and to advocate the opening of what is, in fact, a Space Frontier.

The National Space Society does fully support this year's Administration budget request for NASA of $13.3 billion. The message that the National Space Society wants to convey to the Subcommittee today is not one of technological arguments and budgetary wizardry, but is in fact a plain and simple message of vision that is in what we feel is the tradition of the American dream and the tradition of the American spirit.

We believe that the United States must be a leader on the Space Frontier or it will cease to be a great hope for human liberty and freedom.

Public opinion polls we feel definitely support the position of this citizens group, that there is a common vision of the American people, a common vision that probably grows out of our frontier heritage. And that vision is for this nation to continue to open frontiers, to develop frontiers for not only our benefit but for the human benefit. All mankind's benefit.

The nation's goals we feel have been stated and stated pretty succinctly by the President's National Space Policy Directive of last year.

Now, when I say that, I am really particularly and specifically talking about goal No. 6 in that Presidential Space Policy Directive. That goal states that:

This nation will expand the human presence beyond Earth orbit and into the Solar System.

Now, that's a pretty expansive goal. And we feel that it, in fact, covers succinctly what the American people want to see and what this nation needs to see as a future in Space.

It sets no specific time lines. It sets no specific program. In fact, what we feel is yet necessary is an integrated strategy to fulfill that goal and the other goals of this nation's Space policy.

Specifically, we think that such a delineated strategy, when it happens, by necessity almost will look like the kinds of strategy established and set by Dr. Paine's National Commission on Space.

We feel, the National Space Society, feels that this country's Space enterprise is, in fact, a social program. It benefits our society by providing jobs. It promotes the general welfare and secures our freedoms.

It challenges our creative initiatives and instincts. It harnesses our esprit de corps to transform a frontier—Space—into a medium of exploration and as a locale for, yes, business and commerce of the future.

To assist you, this Subcommittee, in making the requisite decisions that will begin us down the path of the next 30 and 50 years and more in terms of productivity and jobs, I want to point out a study that has been completed by the NASA Alumni League.*

In this report just completed, which, incidentally, will be updated with 1990 NASA procurement estimates very shortly, this study shows that NASA procurement expenditures in 1987 immediately generated 210,000 private industry jobs and twice as much business activity as the agency spent within a year.

That's saying that there is a multiplication factor that was clear and statistically present of double the actual dollars in NASA procurement.

The Space Agency's $8.6 billion procurement resulted in 17.8 billion dollars in sales within private industry, including over $2 billion in corporate profits, and $5.6 billion in federal, state and local government tax revenue.

And that's for one year's procurement.

Agency spending created significantly more blue collar and lesser skilled jobs than it did the traditionally accepted scientific and engineering job. This report clearly demonstrates that the industry sales and jobs impacted every State, benefitted every State in the Union.

The biggest winners, I might mention, that come out of this analysis, are some that few analysts usually see as being tied to the Space Program: New Jersey, Arizona, Kansas, Illinois, Tennessee, Wisconsin, Michigan, North Carolina.

Major conclusions of the study are that the total economic employment benefits are between two and three times larger than is usually assumed, that 80 specific industries are significantly affected, and over 247 occupations are significantly affected by NASA-stimulated employment.

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*Appendix 9 contains NASA Alumni Report. See p. 1188.

In broader terms, the opening of the Space Frontier repeats in many ways, we think, the historical uncertainties that surround previous explorations and developments within the Continental United States.

But, since earlier times, explorations and new developments have always been met by skepticism and uncertainty in terms of value, the potential of the risk involved, and certainly even questions about whether the fortitude is there to tame a new environment.

Today, Space represents a competitive territory for commercial opportunity. It presents us with real opportunities for new wealth. We can't ignore that. The rest of the world isn't.

Simply put, given the pioneering spirit that opened up previous frontiers, the economic expansion that is waiting for us in Space is probably as unbounded as Space itself.

The National Space Society also wishes to suggest to this Subcommittee that a political framework for Space support is there and is ready to be filled in.

Space will help this nation in such diverse areas as the environment, education, economic competitiveness, international cooperation. NASA and academia are the fledgling interests, and other fledgling interests should play a key role in supporting Space in this nation. And we urge that everyone, given whatever platform that they have, put Space into the political dialogue as it embraces all of these areas.

The National Space Society notes that the gathering support for Mission to Planet Earth is not only strong, but is vitally necessary.

Mr. Chairman, you and myself, thank God, are some very fortunate individuals who have had the opportunity to look at the Earth from Space. And I believe that you will agree with me that it is such a rare jewel and probably in this universe, as far as we know now, it is a totally unique jewel of life. And, certainly, as I saw it in Space, moving as a space ship of its own, the Earth with a halo of atmosphere surrounding the sphere with the seas and oceans of deep blue and azure and green, the land that's infinitely textured, that is covered with a variety of green life or sandy soils or white snow, that it is perhaps the most beautiful thing that the eyes have beheld.

But I know that I saw signs of concern. The atmosphere in more than one locale is blotted by smog and haze. The rivers and the seas are more than in one place discolored by silt and other pollutants. And that's clearly visible.

The planet is really showing signs of wear. We need to better understand the inter-relationships of man and our environment. Mission to Planet Earth will allow us to do that.

The National Space Society strongly urges this Subcommittee to assist in the implementation of multi-agency planning, to globally sense our environment; the planet vitally needs an examination.

The rescue of the Landsat Program from an illogical early demise was certainly applauded by our membership. But it's only a beginning, only a small beginning. And there can be no end to Mission to Planet Earth.

In fact, we, as the National Space Society, look forward to a time when space travelers and, in fact, perhaps occupants of other communities, human communities off Planet Earth, can return home and find an environment as pristine as our forefathers had it.

Early this year in Phoenix, Arizona, I had the pleasure to cochair along with our Board of Governors Chairman, Hugh Downs, a meeting of this Society's board members and invited dignitaries.

At that time, we had not only an Apollo Moon Walker, we had a movie producer, an actress. We had an artificial intelligence expert. We had both present and former members of Congress visiting with us. Together, we crafted a document which observed that: Humankind is indeed entering a new era of dramatic exploration and discovery.

Humanities very future will depend upon the exploration of the Solar System.

It was felt by that group and by this Society that this country has studied for too long the future that it might like to see. That group decided and stated that it is, in fact, time for this nation to enter into a decade of doing.

The United States leadership has floundered, in fact, in the last 20 years in the Space arena. In 1973, Skylab became this nation's first long-range plan for Space occupancy. This is all that's left of Skylab today, a fragment picked up from the Australian Outback.

The Nation's plans and goals have, in fact, floundered. The commitment has not been there. We see that the commitment needs to be restored, and it needs to be bolstered.

The National Space Society would like to offer some specific objectives. First and foremost, the Space Station Freedom Project is one that this nation must proceed with with vigor, must proceed with apace, because it is the stepping stone to the rest of the universe, whatever we want to do there.

And that should be conducted concurrent with Mission to Plant Earth. No one wants to leave the planet and have any doubts that there's going to be a worthy home to come back to.

And we wish to enumerate a long-term civil space objective. It's an over-arching objective. We wish to enumerate that, in fact, the expansion of the human presence and activity beyond Earth into the Solar System is what we are all about and need to be all about, that the establishment of a permanent return to the Moon as the next step after the Space Station freedom will support eventual human missions to Mars and beyond. And that all of that is a requisite part of our future.

The Space Society sees this objective and goal as a necessary step on the way to opening up that Space Frontier.

By clarifying our objectives and by adopting, in fact, the 1986 recommendations of the National Commission on Space, this nation will be building upon 30 years of Space experience.

And this year, you know, is a very important year in coming out of the doldrums, so to speak, coming out of that dark time between the thought and the action.

Voyager II will be encountering the eighth planet of this Solar System in August of this year. This year, in April, this month, there will be a launch to Venus, a probe named Magellan. Galileo will be launched to Jupiter in October of this year. And in December, if all goes well, we can at long last expect to see the historic Hubble Space Telescope placed into orbit.

For 15 years, we can expect to see that Space Telescope, updated by robots and astronaut crew, replacements of equipment and experiments. We will see a Space Telescope that is, in fact, not a telescope at all. It's a microscope.

The Hubble Space Telescope or microscope will in fact allow us to look back in time and down to the most minute origins of the Universe. We are going to see back into the cosmological record like no human beings have ever seen before.

In summary, the Space exploration and development is part and parcel I think of this nation's future. The benefits are going to be there for us and our civilization—economically, educationally, environmentally, politically, socially and spiritually.

The greatest spinoff of our Space Program, we feel, is not the tangibles like Tang or Teflon or even jobs. The greatest spinoff is not the intangible, like leadership. What, in fact, is the greatest benefit, the greatest spinoff of our Space program is its uniqueness as a positive vehicle for this nation's future in Space.

The underlying message here is:

The National Space Society is a family of citizens, grassroots organizations, is here to be an advocate for Space and to help this Subcommittee, this Committee and the entire Congress support its deliberations and its decisions with regard to this very important issue of our nation and of humankind.

Mr. Chairman, again, I want to thank you for the opportunity.

[The prepared statement of Mr. Walker follows:]

NATIONAL
SPACE SOCIETY

STATEMENT OF
CHARLES D. WALKER
PRESIDENT AND CHAIRMAN, EXECUTIVE COMMITTEE
NATIONAL SPACE SOCIETY

ON THE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1990 BUDGET REQUEST

BEFORE THE
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

APRIL 5, 1989

922 PENNSYLVANIA AVE. SE
WASHINGTON, DC 20003
202/543-1900

Mr. Chairman, and Members of the subcommittee:

Thank you for this opportunity today to express the hopes, dreams and aspirations of the National Space Society before this hearing on the institutional issues facing the National Aeronautics and Space Administration. The Space Society is a growing organization, representing the shared vision of upwards of 25,000 members and 125 chapters primarily situated here in the United States.

The National Space Society is a family of organizations which includes the non-profit educational 'mothership', NSS; the grassroots lobby, Spacecause; and the political action committee Spacepac.

So you can see that space advocates are beginning to organize in much the same fashion as many other politically astute advocacy groups have done in the past. Space activists are determined to become major players on the public policy stage.

Our vision is clear: to create a spacefaring civilization which will establish communities beyond the Earth; to promote the exploration and economic development of space; and to advocate the opening of the space frontier.

One step to realize this vision -- a vision common not only among our members but, we believe, this nation as a whole -- is that the National Space Society fully supports the 1990 Bush Administration budget request for the National Aeronautics and Space Administration of $13.3 billion.

The message, then, that the Space Society's members wish delivered to the members of this subcommittee and your colleagues throughout Congress is not one laden with technological arguments or of budgetary wizardry. It is a message, plain and simple, in the tradition of the American dream and the American spirit - we believe that United States must be a leader on the space frontier, or it will cease to be the great hope for human liberty and freedom.

Public opinion polls and the National Commission on Space, heard our citizenry clearly articulate their common vision of an open frontier in space...they want Americans in space...carrying out a human adventure...pushing expansion as an economic necessity.

As to the frequent calls for another review of our nation's goals in space or a study on our space program -- we call for a moratorium on the like. This nation's goals in space were stated succinctly in the President's National Space Policy Directive. What is needed is an integrated strategy to achieve those goals, Such as was delineated by the National Commission on Space. The nation should quickly develop that strategy and get on with our nation's destiny in space.

Further delay only exacerbates the many problems we very likely would experience as a second-rate space power. The long term consequences of our near-term decisions dictate that we justify funding for the civil space program.

We wish to submit to you that the United States can no longer afford to weigh social programs against the attributes of the space program. Our space enterprise is a social program...it benefits our society by providing jobs. It promotes the general welfare and secures our freedoms. It challenges our creative instincts. And it harnesses our esprit de corps to transform space into, not only a medium for exploration, but as a locale for business and commerce.

As you know, the United States has been engaged in exploring and utilizing space for over three decades. To assist you in gauging just what that thirty years means in terms of productivity and jobs for the country, I would like to call your attention to a recently issued study by the NASA Alumni League.

According to the report, which, incidentally will be updated with 1990 estimates on April 20th, NASA procurement expenditures in 1987 immediately generated 210,000 private-industry jobs and twice as much business activity as the agency spent within a year. The space agency's 1987 $8.6 billion procurement resulted in $17.8 billion in sales within private industry, including over $2 billion in corporate profits and $5.6 billion in Federal, state and local government tax revenues.

Space agency spending, for example, created significantly more blue-collar and lesser-skilled jobs than it did for the scientists and engineers traditionally associated with space activities.

This report clearly demonstrates that in terms of industry sales and jobs every state benefits substantially from the U.S. Space Program: indeed, most of these benefits went to states other than those receiving the prime contract awards. The biggest state "winners" include many that few analysts perceive as being closely tied to the Program, such as New Jersey, Arizona, Kansas, Illinois, Tennessee, Wisconsin, Michigan and North Carolina.

Among the major conclusions of this study are:

- The total (direct plus indirect) economic and employment benefits are between two and three times larger than is usually assumed, and are much more pervasive than is generally recognized.

- The major beneficiaries--specific industries, occupations, and states--include many which have heretofore not been linked closely to the Space Program or to NASA procurement.
- The 1987 NASA procurement had a multiplier effect on the economy of 2.1 for the entire nation, and 14 states had a multiplier effect of 2 to 1 or greater, ranging from 12.1 in Indiana to 2.2 in New Jersey.

This type of analysis, while based on well established and validated economic methodology, has never before been applied to the U.S. Space Program or to the NASA budget. The findings of this study are crucial for emphasizing the total (direct + indirect) economic benefits of NASA Programs to the nation as a whole and to individual states and cities...in defending NASA budget requests...and in justifying increased Federal spending for an ambitious Space Program during the 1990s.

In broader terms, opening the frontier of space repeats in many ways the historical uncertainties that surrounded previous explorations in this country.

Recall the epic journey of Lewis and Clark, the acquisition of new land through the Louisiana Purchase, or the investment needed for that "frozen wasteland" called Alaska, better known in history books as "Seward's Folly".

Since earliest times, expansion into new regions are met by skepticism and uncertainty of value, potential for high risk, and fortitude required to tame an unknown environment.

Today, space represents a new competitive territory for commercial opportunity. New goods and services for people here on Earth can be derived from space commerce. Tapping the unique vantage point of space can lead to prospecting for new energy sources, and better stewardship of our globe's delicate biosphere.

Further, the vacuum and microgravity found in Earth orbit may lead to improved manufacturing processes or techniques to produce superior electronic components to life-saving pharmaceuticals.

Simply put, given the pioneering spirit that opened up previous frontiers, in this our newest arena economic expansion may be as unbounded as space itself.

The Space Society also wishes to suggest a political framework for space supporters - NASA programs complement domestic and international initiatives of both the Administration and the Congress. In areas as diverse as the environment, education, economic competitiveness, and international cooperation issues, NASA and our nation's fledgling commercial interests can and should play a key role. We urge you to make this point a part of the political dialogue.

The Space Society notes the gathering support for Mission to Planet Earth as an objective for the country's space program. My own experiences, accumulated during three Shuttle missions, have greatly strengthened my kinship with this exquisite Earth.

The Earth moves in space, clearly a spaceship itself. The atmosphere is a thin blue halo at the edge of the Earth's sphere. The seas and oceans are jewel-like with deep blue azure and green. And the land: infinitely textured, covered with green life, ruddy sands or white snow. But there are signs of concern. The skies are stained and smeared by haze. Rivers and seas are discolored with the silt from forest-cleared land.

Our home planet is showing visible wear - we must understand better the interrelationships of man and the Earth's environment on a global scale.

We strongly urge this subcommittee to assist in the implementation of a multi-agency plan to globally sense our environment and better evaluate the stresses and strains placed on our planet by our species. Our planet is painfully overdue for an examination.

Indeed, we should not only implement an international, global health check of our world, but we must maintain systematic, ongoing programs to evaluate the condition of our planet.

The rescue of the Landsat program from an illogical early demise was applauded by our members, and we hope that a long-term solution can be found for its funding problems.

There can be no end to Mission: Earth...we must maintain our earthbound "launching pad" while we peer spaceward. When celestial travelers from Earth return to the planet after a long voyage in the distant future, they should find their home planet as pristine as when they departed.

Early this year in Phoenix, I had the pleasure of co-chairing with our Board of Governors Chairman, Hugh Downs, a meeting of the Society's Board members and invited dignitaries.

At that meeting, comprised of individuals from various walks of life...including an artificial intelligence expert to present and former members of Congress, a movie producer and actress to space scientists and an Apollo moonwalker...we crafted a document which observed that humankind is, indeed, entering a new era of dramatic exploration and discovery. Humanity's very future will depend on human exploration of our Solar System.

More importantly, this group declared that we have studied far too long where we can go in space. We must now embark on the grand adventure that awaits by initiating a "Decade of Doing."

But let me offer some specific objectives. The National Space Society considers as paramount the Space Station Freedom project and a concurrent Mission: Earth program. We wish to enumerate a long-term civil space goal:

The expansion of the human presence and activity beyond Earth orbit into the Solar System. Establishment of a permanent return to the Moon as the next major step after the Space Station Freedom would support eventual human missions to Mars and beyond.

The Space Society sees this goal as a necessary step on the way to opening the space frontier. From such a permanent lunar outpost, the Moon's resources can be processed to help reduce the cost of space exploration and development. Processed oxygen, derived from lunar soil, can accelerate the rate at which future frontiers could be developed. The lunar base would also assist the opening of Mars and its valuable moons by testing and improving space-related equipment and techniques for long duration human space exploration. Lunar development is, in the long-term, the most effective way to explore and develop the entire Solar System for the benefit of all humankind.

The establishment of the Lunar objective will set in motion our governmental space expertise, unleash the creative and innovative talent found in our industries, universities, and colleges, and space the imagination of our youth who hunger for the knowledge that America has a future is space.

By clarifying our objectives in space -- in great measure, by adopting the 1986 recommendations of the National Commission on Space -- we build upon thirty years of space experience. This year alone, Americans will be witness to privately funded space launchings; a fly-by of the mysterious planet Neptune by our Voyager II interplanetary probe; the launchings of the Magellan probe to Venus and the Galileo spacecraft to Jupiter; and the deployment above the Earth of the historic Hubble Space Telescope.

The anchoring in space of the Hubble Space Telescope deserves special attention. In many ways, the Space Telescope is not a telescope at all. It is a microscope : the Universe can be explored in the most minuscule of detail. Hubble is also a time machine to further our knowledge of our cosmic origins and perhaps our cosmological destiny. Its light gathering power and host of sensitive equipment will enable us to explore the possibility of other planets circling distant stars.

In summary, space exploration and development is part and parcel of America's future. The benefits of becoming a spacefaring civilization are economic, educational, environmental, political, social and spiritual. What we learn as humanity ventures into space can provide new perspectives on the global environment and bestow both domestic and international benefits for the well-being of all.

To repeat: the greatest spinoff of the space program is not the tangible: teflon, and Tang and jobs. Nor is it the intangible: the promise of pharmaceuticals or faster computers.

No, the greatest spinoff of the space program is its uniqueness as the vehicle to our future in space, the next frontier.

An underlying message we would like to leave with you today is for the members of the Congress to utilize the resources of the new space advocates -- the National Space Society - as a trumpeter of national opinion.Call upon us as advocates for what you and the people believe.

Through our family of organizations we can help this subcommittee communicate with other members of Congress in shaping our nation's space endeavor. National Space Society's leadership and our entire membership are communicating the importance of space to all levels of society, ~~from~~ the halls of the Congress to schools and meetings in communities across the country and the world.

Mr. Nelson. Thank you.

I want to turn to our members. Mr. Schiff is first in line. I'm going to ask Mr. Torricelli if he would chair so that I can go on to the Banking Committee.

I might say all of your testimony has been excellent. It's been very visionary. And that's what we need.

I'm curious, Dr. Paine. I think Mr. Torricelli, if you've got any insight later on, he's going to be wanting to find out about any of your commentaries about the Soviet Program, perhaps with regard to the most recent Phobos problem.

Mr. Walker, basically, this Committee is not sure that we should go back to the Moon before we go to Mars. That is an open question for the Committee.

And part of the vision that you have articulated so well here today is giving this nation a goal that will really rev this nation up.

Mr. Fuqua, Chairman Fuqua, was talking about we need to have the spirit of Apollo again. And I think we're going to have to set that goal.

In my own personal opinion, it's to go to Mars with humans.

And in my own personal opinion, it's on an international mission. And that we proceed. And that we go do it. And that, unless we set a goal for ourselves that really stretches our limits, even though going back to the Moon and setting up a base and so forth would be stretching our limits, but we're talking about what each one of you have spoken about, of capturing the imagination and creativity of the people of this planet. And stretching ourselves to the limit to achieve that.

Now, that's what I want to see the President of the United States set as a goal for this country. And only he can do it. And you all have certainly helped us as we have tried to sort through all of this.

And then we have to get down to the number-crunching and the daily oversight activities, and so forth. So it's nice to sort of rise above all that, as you all have enabled us to do today, and think big thoughts and think visions of sugar plums in our heads.

And so I appreciate it very much. And let me turn it over to Mr. Torricelli, and thank you again. This has been an exceptionally fine set of testimony.

Mr. Torricelli [presiding]. Thank you, Mr. Chairman.

I believe the Chairman has recognized Mr. Schiff first for a question, if you would?

Mr. Schiff. Thank you, Mr. Chairman.

Mr. Chairman, because off the number of Committee members—Subcommittee members—I see here, I'll be brief as I can be. There's one subject I would like to address to the whole panel, if I could.

I want to let you know that although of course the former Chairman I recognize, and the gentleman, as previous experts, you've been here before, I haven't. I'm a new member of the Congress and I'm on the Energy Research and Development Committee. I applied for that because that is important to my District and something I think is important to the nation.

I volunteered for this Subcommittee when there was an opening because I want to be supportive of the State effort.

However, there is a problem. And I would throw it open to all of you to assist me. The problem is:

First of all, in a poll I took of constituents, my very first poll on the various issues—What should we support? What should we not support?—the Manned Space Station came out not too well.

Less than half my constituents who responded to the questionnaire were supportive of the Manned Space Station. Further, I saw a poll taken by a newspaper—I want to say USA Today, but I could be mistaken about that. But certainly it was a newspaper of national origin, took a poll on what American citizens thought across-the-board.

And, indeed, there was a feeling that we were spending too much on the Space effort. I think the Space effort came in ahead of foreign aid, but that's about it.

I don't know that I'd brag about that, given what my mail reads about foreign aid.

I get the impression that it's entirely a cost factor. I get the impression that the problem is:

How can we be talking about exploring Space when the Administration recommends zero cost of living increases for retired military and retired federal civil service representatives?

I think it's a cost factor of recommending a Manned Space Station when there has been testimony which I have witnessed in this Subcommittee that we could do much in the way of much cheaper unmanned exploration at the present time. It wouldn't be as perfect as manned exploration, that's conceded. But it would do a great deal at a much reduced cost.

And the feeling that the emphasis which I've heard today on the U.S. leadership in Space research is perhaps not appropriately placed any more. Perhaps we should recognize this as a human concern and that other humans on this planet should share with us the greater cost of the exploration, than at least it's believed they are doing.

The point is, and the bottom line that I throw open to you is:

I want to be supportive but I'm reading a big negative from the people in general and the people I represent.

I wonder if you could assist me in what to present back to them.

Especially on the cost relationship issue. And I might add—excuse me, gentlemen. I know I asked a question and interrupted you. I apologize.

I might add that, of all the arguments, the multiplier issue is the weakest in the sense that we could get a multiplier effect from any expenditure. I can't justify this expenditure.

But I would be interested in what you can give me because I want to be supportive of the effort.

Mr. WALKER. If I might kick it off, gentlemen.

Mr. Schiff, I would respond to your question in a couple or three different manners. First of all, I certainly want to make available to you, your staff and the entire Subcommittee copies of the NASA Alumni League report that I mentioned in my testimony. And the statistical methods to find there that it utilizes.

I think, and the multiple factor that I mentioned to you of 2 is a nationwide factor, in fact, the numbers in every State are different because the economic determinator there is the benefits locally of the total benefits divided by the direct benefits.

But, to be more specific, the multiplication factor varies anywhere from almost 2 in some States, some locations, to 15 in some States. And I dare say that there are not that many federal programs that can show that kind of multiplication effect.

With regard to the citizenry, I think we have to be careful. There has been more than one article recently about the kinds of polls that are taken in this country. It seems to be a fad to take polls these days. And, in fact, in terms of verifiable polls, there are certain techniques that do work and create valid numbers, and there are certain techniques that do not.

So I think all of our polls need to be hounded on as questionable to some extent. But, to use polls, as we all do, nonetheless, there was an interesting poll that I saw just a few months back which went into a little more depth with regard to the NASA budget dollars or the Space budget dollars question.

And that poll, in going in more depth, specifically asked:

"How much do you think this nation as a citizen, and a taxpayer, how much do you think this nation is spending on civilian Space Programs?"

Over two-thirds of those responding said that they thought that this nation was spending anywhere from 5-50 percent of its annual budget on civilian space program.

So I dare say that I think most of the American public is not even educated enough to respond to a question of: Do you think we are spending too much on Space in this country?

I think most of the American public has a totally erroneous basis of appreciation of dollars spent in civil space.

Many questions, many polls, have, in fact, showed, and polls that take very large samples nationwide—2,000 individuals and more—do show that, in fact, two-thirds of the American public believes that we need to either continue to expend the amount of money that we are spending now or more, and that they applaud in fact a decision that would spend more for Space in this nation if—if—that expenditure of more would, in fact, maintain leadership in Space for this nation.

I think that the American public are vitally concerned that they are a leadership nation and that they demonstrate that. And that we have to make hard decisions, no doubt about it. There is no one that doubts that one single bit. And hard decision are, by their very nature, difficult and do cause us to have to bite the bullet in many realms.

But I think the American public is, in fact, positive about Space.

Mr. **Fuqua**. Let me just respond because having gone through the election process myself for 12 times to this Congress, you're very attentive to what your constituents say.

But, if you take a dollar bill and if you take and equate how much of that goes into the Space budget, if you just about trim the edge off, that's about how much out of that dollar of the total federal budget goes into the Space Program.

As I mentioned in my comments, I think you have to—one of the challenges that you have and the other members have in this Congress is how you allocate priorities for spending.

I don't have to tell you the pressures on the budget, the dollar, or federal dollar, to go to different places, and most of them all very, very worthy causes—libraries, health care, homeless, AIDS, national defense, all the other many things.

As I mentioned, there are some things that I learned while I was here that you spend money for that's an investment. Some things are an expenditure. And I think you have to determine from a policy standpoint whether or not those things are in the national interest.

And you also are charged in your responsibilities being here of trying to do what you think is best for the country. And the long-range goals, there's nothing that's a greater driver of technology than the Space Program and the multiplier effect of what it has.

You can go back and look at some of the things that have happened in years past that has been a direct benefit of the Space Program.

But I think when you look also at do we plan to be a leader in the world in Space? Or, do we plan to be a follower?

That doesn't mean that we have to be a leader in every aspect of Space, but do we plan to play a leadership role as a world power?

Either we get in or we get out. And I think it's very simple. I think we have to be a leader. In my present capacity now in the Aerospace Industries Association, one of the ways that we can compete, whether it be in aeronautics or space or however, is the fact that we have a better technology than our competitors. It's not going to be trade restrictions. It's not going to be tariffs or all types of artificial barriers that will lead us to be a world leader.

The thing that will lead us is going to be technology and the fact that we can build something better and more economical than our competitor.

And we're living in a global environment today and I think to paraphrase what President Kennedy said, that:

Those—and I'm trying to remember the phrase now, but:

Those that those that tend to be world leaders must also be leaders in Space and, if not, the others will fill the vacuum.

That's not an exact quote, but it was in essence words that he used.

I think you have to look at where it is. As Charlie Walker pointed out, "The polls can play different games."

And there is a perception by several polls that have been made that the perception of the American public is you're spending half of this on Space. And that's not true. They tend to get SDI and Defense and a lot of other things confused with Civil Space Program.

But, Civil Space is a very, very tiny part of this whole dollar.

Mr. Schiff. Dr. Paine, if you wish.

Dr. Paine. Well, I would certainly make several observations. I think one of the difficulties the Committee has, of course, is that you are being asked to consider authorization at a time of great fiscal restraint in this country. Nobody is pleased with the budget deficit. Nobody is pleased with the National Debt.

It's a very difficult time to be funding long-range efforts like Space. And, yet, in the National Commission on Space, we were specifically instructed by your Committee to have hearings all around the country.

And we did. We had open mike hearings. We advertised in the paper, on the radio, asked the citizens to come in and tell us where they would like to see the Space Program go.

And the overwhelming recommendation that we got was for a bold program with inspirational goals. The Los Angeles session, I remember, we had a young student from USC show up and say that he was representing the entire dormitory. They had a meeting the night before. They had instructed him to come and say that they were sick and tired of watching men walk on the Moon on tape. They wanted to see it in real time; why didn't we have a Space Program that would let his generation participate in these wonderful missions?

And I think that our sense of the mood of the public was very definitely ahead of the leadership in Washington. I think the public is ready for somebody to come out just as it was when Jack Kennedy said:

"Let's go to the Moon."

He rejected the Space Station as being not tough enough to challenge NASA to become the leader in Space. He rejected the Mars mission as being too difficult to do. He chose the Moon Program.

I think we need to examine our goals today with that kind of philosophy.

With respect to your constituency, you have a highly-educated, very technology-oriented constituency. I think that they would certainly understand that the Spanish-American opening of the West which made your community possible was done by Columbus actually going down with the Finance Minister and the King and Queen before the Siege of Grenada.

They weren't up in some castle somewhere, they were right there on the firing line having a real question as to the future of their nation. And at that time, they made the commitment to explore to the West, to use the new ocean-going technology which had been developing along the Atlantic Coast to explore, with an enormous impact on the future history of the world.

Since that time, of course, Thomas Jefferson stood up under great criticism for the Louisiana Purchase, taking an opportunity at a very difficult time for Napoleon in Europe to open up the American West.

And we've had government investments in Lewis and Clark, the railroads across the country, and so forth. And, certainly, in your own case, the opening up of the Atomic Age and the Manhattan Project. Certainly, it must have been very difficult for President Roosevelt to set money aside for a crazy idea of Albert Einstein that there might be a possibility of releasing energy from the atom.

And, yet, those leaders made those difficult decisions in those tough times and I think world history changed.

What the three of us are recommending to this Committee is that you continue to make that kind of bold investment on the frontiers of technology to open up for future generations. And of course we're talking about a very small percentage of the federal budget.

It seems to me that a 1 percent Columbus investment would be a relatively modest one to make as we approach 1992, the 500th anniversary. And we're talking about a much smaller percentage than that.

Mr. SCHIFF. Gentlemen, I appreciate your advice and comments. As I said, I want to be supportive of the program. I was just leveling with you as to what I was hearing, how to handle it.

Mr. Chairman, I have no further questions. Thank you.

Mr. TORRICELLI. Thank you, Mr. Schiff.

Dr. Paine, I thought your analogy to 15th century Spain was well-taken and this new reason to be thankful that Queen Isabela did not have the franking privilege nor to poll her constituents. [Laughter.]

Dr. PAINE. I believe that she shared with the present First Lady an interest in pearls and things, much to our advantage. Perhaps Barbara Bush would become a proponent of the Space Program and donate a pearl string or two. [Laughter.]

Mr. TORRICELLI. In a franker moment, Mr. Fuqua served on this Committee long enough that he could have also have suggested that when someone writes to you in a world where there are still millions of people dying of hunger and complains about foreign aid, somebody writes in a world where America is fighting for her economic future, fight for her standard of living, and suggests we shouldn't have a Space Program, there's a form letter that you can send back to them—which I do.

It starts:

"You're wrong. That's what leadership is about."

I'm glad to loan that letter out if anyone would like to use it. Mr. Buechner.

Mr. BUECHNER. I think the common term that you used, Doctor, the one with Mr. Walker, was vision. I know Congressman Fuqua uses it in his speeches. In fact, I noticed that if you see an article in Roll-Call magazine, which is—or paper that's coming out that's going to deal with Space, if you see the proverb—I didn't steal it from you. I stole it from the bible. Okay? But—because I think it does epitomize what we have to convey to the American public.

And Mr. Torricelli says leadership. I guess my problem is not in addressing that because it's easy for me to go to my constituency. I have Missouri as one of the areas that has a great cost-benefit ratio in Aerospace. They understand it produces jobs.

So at the base political formula, it's something that I can go out and promote. The problem is how do I get the rest of the people that don't belong to this Committee to have that same vision, and to be able to fight off the rhetorical games that you can play with "We're not going to have a home in Space until we have homes on Earth for everybody that wants one."

Those are really tough things to fight off. And they lend themselves to letters to the editor and Morton Downey Shows, and all the horrible things that are so great about this country, that you have got the freedom of speech.

And I guess what we need to do though is we need to find a way to take—this is a speech. It's really not a question. We need to find a way to take the enthusiasm of gentlemen like you and the people that belong to your organizations have and then we here in Washington and to take those and find a way to scoop all the people in the middle.

And I would like your comment about two things. Number one, the role of the National Science Advisor to the President. I'd start off—I was going to write a commentary piece, and I was all excited about it. And I realized, you know, the National Science Advisor could possibly not give a hoot about Space and could really start trying to turn the dialogue about:

"Gee, we ought to be spending this money on things here on Earth."

Or maybe just the Voyage to the Planet Earth. That's okay.

And when you listen, as we have, to Carl Sagan, who was here saying: "We don't need Manned Space. We can shoot all of these things up and that's okay. But we use robots and that's the essence of man's control over his destiny, is unmanned Space. And we need to do other things to run Earth."

And I wonder how we go about creating the best atmosphere for the Administration to move forward and for we who advocate Space to move forward.

If you were us and going to call President Bush, what would you recommend that we say to him that's different than what you might think that we're going to say?

Dr. **PAINE**. Well, I guess we can each take a crack at that. Perhaps I'll start. I think that I would make the point that the United States is getting too negative. We're getting too concerned about the environment, the health of our food. We're getting too concerned about our drug problem; homeless. You know, all of those are very difficult problems.

They all have a very strong personal, social, legal factor which makes it very hard for our democracy to deal with them. We've got to deal with all of those questions.

But, at the same time, I think the United States also stands for some very positive things. And we have so many young people in this country that would love to be astronauts, that would love to have careers in science, technology; out on the forefront, they see the role models of people like right here at the table. And that's the kind of direction they want to go.

And we've got to also offer them something. It isn't enough to fix the ozone layer. It isn't enough to monitor Earth. We've also got to push out on the very frontier. That's always been the thing that has characterized America. While other nations have been more concerned perhaps with their border warfare in the little Balkan Areas of the world, the old traditional borderlines, we've been opening up new frontiers, creating new wealth.

I think that someone has observed that probably the greatest housing program ever launched, that built more houses than anything else, was Columbus' voyage in his three ships across the Atlantic.

We've got to create new wealth, new opportunities, inspire the next generation, at the same time we're cleaning up a lot of the problems. And I think that if the new Administration is entirely focused on our problems, they're going to have a very difficult time getting America back on the track where it belongs. It's time we got back to the spiritual, to the inspirational, to the challenging our young people, our scientists and technologists, to work together.

And I completely agree also—I believe Mr. Schiff made the point—that we need to do it in concert with the rest of the world. All of the world looks to America for leadership on the Space Frontier.

To the degree that a President and this Committee and the Congress will back the strong new goals in Space, you'll have every nation in the world saying, "Gee, can we work with you, America? This is the best thing about America. This is the way we like to see you go, and we want to go with you and contribute to it."

So that would be my message to the Bush Administration.

Mr. **BUECHNER**. Charlie or Don, either?

Mr. **FUQUA**. Yes, I would just like to, as we used to say, associate myself with the gentleman's remarks. [Laughter.]

I think Dr. Paine articulated them very well. I would just like to say that, as Mr. Terricelli mentioned, if we as a country, the exploration has been one of the great challenges that we've always had, as he articulated in his previous response to Congressman Schiff.

The fact is that if we are going to continue to push the frontiers back and enjoy the lifestyle, then we must have some type of challenging program that can do that. This is not a WPA make-work type program.

But I might point out all that money is spent right here on Good Earth. None of it is spent in Space. And it provides jobs for people. I was just looking at this—from truck drivers to welders to all types of jobs that are created by any type of technology development program.

But, if we're going to have the technology to stay ahead in so many things—we're looking at another hearing you're having on Superconductivity. Many of the other—Biomedicine. All the many exciting things. There are many things that we developed or were developed in the Space Program that have a direct beneficial effect on understanding those programs.

In my testimony, I outlined some of the things we at AIA in a new foundation we've established. One of them was advanced sensors. That's not necessary—we need that in manufacturing. We also need it to utilize in a lot of our new technology programs.

But, one of the people that called me after we announced this was from EPA and said, "Boy, we really want to work with you on this program because we need advanced sensor to help us understand some of the monitoring in the ozone and the upper atmosphere, and also in ground contamination, so many other things."

So it can help solve a lot of the problems we have here on Earth. And it has addressed a lot of the problems. Look at the Greenhouse Effect and a lot of the others, that we will understand things.

I was looking at some technology recently that may be able—and I think of the recent event up at Val Dez in Alaska. Different technology in developing the bottom booch that can stand shock or these type things without erupting.

This is a lot of technology that we're pushing the frontiers back on. Many practical application things.

So I think we have to take a look at that. I'm proud to say that both President Bush has been a strong advocate of the Space Program. His predecessor, President Reagan, responded in additional budgetary funding for the Program. Not only the last year he was in but, as I recall, throughout the time that he was President of the United States.

The previous President, President Carter, supported the program. We've had some good support from the highest office in the land. These people understand what the big picture is and I think we ought to look at the big picture to look at it.

And I think the members of Congress—it's been my experience—push comes to shove, they understand what it means to have new technology to push the frontiers back, create a better lifestyle for not only the people that live here, but, hopefully, help solve some of the problems that we have here on Planet Earth. And many of those can be not only observed but I think some of the solutions found from being in Space.

Mr. BUECHNER. Mr. Chairman, there's a number of members here. And I know Mr. Walker can share many of his feelings on the same topic, but I yield back my time.

Mr. TORRICELLI. Thank you very much, and it's very considerate of you to do so.

Mr. Skaggs.

Mr. SKAGGS. Thank you, Mr. Chairman.

I apologize for not having been here to hear your statements earlier this afternoon. I've scanned them all.

I infer anyway that you are pretty much of a like mind in support of Space Station as a component of our national mission at this point.

My District includes a large number of engineers and scientists and investigators that are, if you will, much more involved in the small science part of the Space Program.

I'm wondering if you could help me respond to their questions and fears that we're going to be in an environment given budgetary constraints in which Station will, despite our protests to the contrary, serve to, if not squeeze out, at least hold at a constant level and deflated in constant dollar terms, level of the kinds of projects that they feel make a very important contribution to our understanding of the Universe.

Whoever would like to take a shot at that.

Mr. WALKER. I'm being nominated.

Mr. SKAGGS. Okay.

Mr. WALKER. By my peers here, Mr. Skaggs. Thank you for the question because it is an important question, not just for your District, but for the nation.

There are a number, a large number, of scientific investigators not only in corporations, small businesses and industry, but in academia institutions around this country that are interested in seeing scientific knowledge expanded, are interested in looking into the opportunities for new knowledge and even applications that the unique environmental aspects of Space—weightlessness, vacuum and the like—the opportunities that are present there.

And it is a valid concern for them because historically I believe they have felt that they have been pushed out of the arena of opportunity by large program.

But I think in the case of Space Station that really as was the case with the Space Transportation System, Space Shuttle, that this country has and will create an opportunity, a laboratory that will be unique and that will provide them with unique opportunities that they will not have without that kind of facility and without that kind of laboratory.

It takes a manned laboratory to do important things in not only a short period of time, an efficient use of resources, but I think maybe perhaps to do some experimentation at all.

Thomas Edison spent hundreds of thousands of hours tinkering with filaments for what he believed could be an electric light bulb. Hundreds of thousands of hours to find that one element that, machined and manufactured the right way, made a bulb glow and it kept glowing and did not burn out. A robot couldn't have discovered that, not within his lifetime, most certainly.

Technology advances today but there's no better set of tools than these hands, these appendages. There's no better computer than our brain. And when put together, it's going to be a long time I think before our society, our technical society or any other manufactures anything that's comparable in terms of experimenting, tinkering, acquiring new knowledge and applying it.

In a research facility in Space is the way that we're going to achieve that kind of opportunity and capability for this nation.

As in the case of the Space Shuttle, there are going to be nooks and crannies, so to speak, within the launch volumes, within the masses of the payloads that will be flown with that Space Transportation System, and they will be flown to the Space Station.

Nooks and crannies that, as policy today is allowing, can be filled at relatively small cost by small researchers and given unique opportunities therein, not only from the chance to fly them into Space and get them back, but also to have human interaction with them while they're there.

A launch on a rocket that only visits Space for seven or eight minutes isn't going to give a researcher the kind of opportunity, isn't going to give a researcher the tens or the hundreds or the thousands of hours of research time that it may take to acquire that, in fact, verified new piece of knowledge, that new discovery; or give them that new application that they can apply.

I think the Space Station is vital. I think that we do, in fact, have to make a conscious—to avoid lazy practices, if you will—lazy practices in making it the focus for science, an infrastructure that allows then no small participants, or it makes it very difficult for small investigators to be a part of it.

They can be. They should be. Policy and program implementation, announcements of opportunity, support for the small investigators in terms of dollars to help them along. And certainly procurement and planning activities that get them there are going to make it possible.

Those aren't approaches that lend to a lazy atmosphere of support to a major program. There has to be a significant amount of effort put into making that happen. But, without the facility there, it's not going to happen no matter what kind of opportunity they have.

Mr. **Skaggs**. Thank you. Let me ask one further question. And I guess, Dr. Paine, I'll toss it to you, if I may, sir.

Listening to NPR yesterday morning, Dr. Fletcher was on forecasting the imminent brain drain from the agency due to both salary and new conflict of interest rules.

How serious a threat is that to the future of the agency? What should we be doing about it? Given I think the theme that ran through all of your statements that our strength here is knowledge in people's minds. And if we're losing some of those best minds, where do we go?

Dr. **Paine**. I think that Dr. Fletcher's concern is, indeed, a very real concern. We are facing a sort of a mass obsolescence where a number of people are simultaneously reaching retirement, so that we do indeed have to be concerned.

And I think this Committee is going to want to keep a very sharp eye indeed on the level of technical competence and capability.

However, without over-reacting to the situation, one of the things again which we did on the National Commission on Space was to hold meetings around at a number of the NASA Centers and then we asked all of the senior people from those Centers to leave the room and we invited a number of the very young people, people who had only been joining NASA for about a year, to come in and talk to us about how they saw NASA, how they saw their careers.

We tried to get a spectrum, not just the top bosses in NASA. And I must say we were very encouraged indeed by the level of competence and the drive and determination and high motivation in the young people around throughout NASA.

My own feeling is that, as the older people retire, there are a number of very capable people waiting to take their places and, although we'll have to keep our fingers crossed a little bit because of the large numbers involved, I, myself, am reasonably optimistic that getting a lot of new blood in and replacing some of the older people may actually be a plus in many cases.

However, I would come back to the basic tenor of my remarks today, which is that I think that, in order to really get the agency moving and challenge the new management as it comes in to move in the right direction, we need to give more attention to setting NASA the right, long-range goals.

I think that an agency that knows where it's going is going to be a lot easier to manage, including the new people as they take their places, than an agency that has a whole bunch of rather short-range objectives and constant annual reshuffling about which one is the more expensive, depending on who found out about the ozone layer last year, or about CO_2 next year.

We need to have that longer-range thrust which will make it much easier to attract the kind of people to devote their entire professional career to NASA and, at the same time, will help the management of NASA to focus their efforts to get them working together along the lines that you deem to be in the best long-range interest.

That must be a balanced program. It can't be an all manned space flight program. It can't be an all robotic program. You hear arguments at both of the extremes. The real answer is we want to use the best combination of people and machines to get the job done, to achieve the goals that you set for NASA in the most efficient and cost-effective way.

That invariably will involve manpower as well as machines. But it will involve a very heavy percentage of highly-automated advanced artificial intelligence type of machines, too. That's a darned good thing because as NASA moves that frontier back on the Space missions that it has to perform, it's what's helping the whole country with respect to the productivity and economic growth of the next century.

Mr. **Skaggs**. Thank you very much.

Thank you, Mr. Chairman.

Mr. **Torricelli**. Thank you, Mr. Skaggs.

Mr. Packard.

Mr. **Packard**. Thank you, Mr. Chairman.

In a tight budget year, and certainly, Mr. Fuqua, you, with your previous experience, understands our dilemma. Do you have, as any one of you, have recommendations on how we would change our priorities in our national budget or our Space budget?

Are there things that we ought to reduce our spending in to benefit other programs that ought to be increased? Other new projects that we ought to bring on line and drop old projects?

Any comments? How about Mr. Fuqua?

Mr. **Fuqua**. Well, thank you, Mr. Packard.

I think one of the things that—and I mentioned it in my testimony, and the Committee has been addressing that. The Subcommittee and both the full Committee—is having continuity to programs.

One of the most inefficient things that we can have is where you have up and down programs or change your mind or switch gears. I think the programs must be well thought out and, conceived properly, analyzed. And then once they have been agreed upon, then we must move forward in an orderly fashion.

When you have inconsistency in funding, funding this year and down next and up next, it makes it very expensive for those programs and, in the long run, our stretch-out in programs.

I have observed some programs since I left Congress in looking at funding level, that some programs it would be better to even cancel the program than to do certain types of stretch-outs that we do, that you just add a lot to the cost and really the program suffers tremendously and loses support because of financial increases, or cost increases that happen.

Mr. **Packard**. Would you recommend that we consider for at least Space and science and research long-term projects, that we consider maybe a five-year budgeting program?

Mr. **Fuqua**. I know the complexities of that. But speaking from an ideal situation, yes, that would be good if you could have that.

Then, the agency and the industry could plan much better and efficiently how to utilize their resources than they could on the one-year budget cycle that we have now.

Now, I know that the Committee has been trying to look at a two and three-year budget cycle and I will commend you for that. I think that is absolutely——

Mr. PACKARD. Even that would be short-term in terms of some of these longer projects.

Mr. FUQUA. It's still short-term, but I understand the complexities of the Congress in trying to go much beyond a program of that type.

But I think consistency in funding is the way that you can maximize efficiency in a program.

Mr. PACKARD. Let me be specific on some programs then. There's some talk now about reducing or dropping the funding for the advanced solid rocket motor.

What's your feeling about that?

Mr. FUQUA. Well, I'm not really here to speak about specific program, but that's one I think, you know, that the Committee is going to have to look at.

One of the things though that I think we have to look at, and I mentioned in my comments, is how can we reduce the cost of getting to and from Space?

That is one of the biggest things I think or challenges we have facing us. We, not only in Congress and NASA, but also in industry, must work very hard at how we can reduce that cost. Otherwise, as I mention in my statement, we are going to price ourselves out of the market.

So I think those things that can add to a reduction of cost of getting to and from Space should receive rather high priority.

Mr. PACKARD. Any comments from other members on that point?

Dr. PAINE. Well, I can't help a little feeling of deja vu because I sat in this very chair 20 years ago and had the same question asked of me, because as we reached toward the end of the Apollo Program, one of the things we were doing was work on very large solids, work which eventually led to the Space Shuttle boosters.

At that time, we decided that, for the reason that we needed to have a technology base that included the various alternative propulsion systems for moving out into the future lower cost launch systems, that we'd better keep that going a little longer and make it prove itself.

So I think the answer to your question is really to raise the question one level to the Space propulsion technology base, and ask the question of the large solid then in the context of is it a vital part of making sure we can move forward to lower cost launch systems in the future?

What part will it play in supporting the joint NASA/Air Force automated launch system? What part does it play in an upgraded Shuttle? But, in the broad context of the space propulsion technology data base.

My own judgment would be that it would be a mistake at this time to cut it back very much until we had a much better feeling for how that technology base is going to develop.

But, again, I come back to the point that until we have a better feeling for where we're going in Space in the long run, in the sense of long-range goals, it's very difficult to know what future payloads we're going to have. And if we don't know what the future payloads are we're going to have, it's very difficult to work back to what launch vehicles we're going to need.

If we don't know what launch vehicles we're going to need, then why is that technology important?

So I would plead again for taking a very long-range look at where we're going.

Sure, a five-year budget would be great. I'd like to see this Committee ask itself where it expects to be 10 years from now. And make a general judgment that, well, if the average NASA budget over the space of a decade of the nineties goes from $13-17 billion, that's an average of $15 billion a year, you're going to spend $150 billion in the nineties, that's two Apollo Programs. What do you want to get back for that?

Then I think your question can come in the context of if that's where we're going, then here are the propulsion technology we need and this is the part that solids would play.

Mr. PACKARD. Do you think we ought to develop more coalitions and consortiums with foreign countries——

Dr. PAINE. Yes.

Mr. PACKARD [continuing]. As we have with the Space Station?

Dr. PAINE. Yes.

Mr. PACKARD. To get some of these big projects off the ground?

Dr. PAINE. Absolutely. You're right on. When you're talking about trying to save money, one of the foreign countries I'd start working with is the one across the Potomac called the Pentagon. [Laughter.]

I think that we don't have enough of an interaction right now between the military space and the civilian space program. I think we need to take a good, hard look in the Mission to Planet Earth, at the relationship between NASA and its Earth observation.

And NOAA, which has a wonderful laboratory out in Colorado, has a very high degree of expertise on climatic and weather situations. We need to integrate some of those things. And then we need to say:

Here is the United States Program, and then invite the other nations to come in and join us. But, no nation is going to join us unless we know where we're going. We have to tell them what our program is and invite them to join us. And to the degree that we can do that, yes, we can save money, too.

Mr. PACKARD. Thank you.

Mr. TORRICELLI. Thank you, Mr. Packard.

Mr. Perkins.

Mr. PERKINS. Thank you, Mr. Chairman. First of all, I would like to apologize to the panelists because, unfortunately, as I'm sure Don knows, you sometimes get a long list of people that you have to meet with in your office and it prevents you from coming to hearing things that you really want to be present at, and want to listen to. And, secondly, I'd like to say it's good to see my old buddy, Don Fuqua, again.

You stay away too long, Don. Come back more often, my friend.

No, I do want to just talk a little bit about something that's always piqued my interest. You know, the National Commission on Space Report, as I'm sure Dr. Paine knows, is one of the, at least in my opinion, one of the most important documents that we've seen produced in the last, certainly, decade.

And a large number of its recommendations have essentially gone by the wayside and very few have actually been filtered into the process. It seems like it has had a definite effect.

And one of the things that seems to be being talked about here today is long-term goals. And the question of, well, one of the things that I got out of that report in reading it is:

Where are we going to be is going to determine how we're going to get there, and how we're going to get there is to determine what we're going to need to build and what programs we're going to need to have today.

And so I've always had a little prejudice towards these long-term goal ideas. It's difficult certainly in a government as ours to produce something like that. Certainly difficult from the Congressional level. I'd just like to hear some from the panelists in terms of what do you think the long-term goals should be? And let's specifically include Mars there. What do you think about Mars?

Mr. WALKER. Mr. Perkins, I would respond to your question by saying that I think that this nation and mankind can have no longer-term goal or no more expansive goal than that which was one of, in fact, a list, the last goal listed by President Reagan's Space Policy Directive a year ago, and which the National Space Society that I am representing here today firmly believes in, which is the goal to see humanity and the human presence extended beyond Earth orbit into the Solar System.

And I think that that is a long-term goal that is appropriate. And that within that context, we then can establish for ourselves as a nation—and, yes, to respond to Mr. Packard's question about international participation—most certainly—because in the context of Space, the Earth is one planet. We are all one race. And that humanity will be there in the long-term as a single entity.

We can in more near-term practical context leverage any one nation's presence and interest there by having a lot of involvement and a lot of investment from around the globe.

But we can look at that long-term goal as a series of steps, as a series of necessary steps, if we are, in fact, serious about a long-term permanent commitment to humanity's place within the Solar System and, eventually, I am sure, even beyond, then we need to develop the resources along the way so that——

Mr. PERKINS. Build the infrastructure.

Mr. WALKER [continuing]. Exactly. And a single trip does not burn us out, as our first landing on the Moon.

Mr. PERKINS. That's how you perceive the first landing on the Moon. We had a goal. We went there. We didn't have the infrastructure after the goal was met; we essentially fell back. We didn't know where to go after that.

Mr. WALKER. And more than that, we not only lost the public interest to a significant enough extent, because they saw the objective as it was stated—clearly, simply, with force—met. And at that point in time, the interest on the public's part and certainly I believe the interest in terms of the leadership in the Administration in place at the time to do anything of significance further.

We can't afford to have that happen in this arena again in the future. And so I think we have to have a clearly-stated, long-range enough goal that we can do everything that we want to do carefully, judiciously, economically at the appropriate time along the way. Step-wise.

Mr. PERKINS. You see, I hear the logic of both points of view. Dr. Paine, I'd like to hear your response to that.

Dr. PAINE. Well, in the first place, I think I would agree with it. I think the problem is to set the right goals. And in the case of the Apollo landing on the Moon, I think we have to go back to what the real goal was, and I don't believe actually it was the Lunar Landing.

The reason why President Kennedy set that goal was to make America preeminent on the New Frontier of Space. He wanted to make America the foremost Space-faring nation. In order to do that, he set NASA the task of landing men on the Moon, because there was no mission, he said, that would more pull together the entire Space-faring requirements and demonstrate them. And that was achieved.

Now I agree as we now move forward, we have that Space-faring capability. The new type of goal that we should be setting ourselves is not an Apollo mission to Mars. That would be a big mistake and would, indeed, repeat the Apollo mission to the Moon to another body. That's not enough.

What we should now be talking about is opening up a Space Transportation System to low Earth orbit that will greatly reduce the cost and hazard of flying to orbit.

Mr. PERKINS. Essentially, following the steps that were outlined in the Commission report.

Dr. PAINE. Step by step. We should have a Spaceport in low Earth orbit that will support flights across to other worlds, namely, the Moon and Mars. We should then build that bridge between worlds with Spaceports orbiting both Mars and the Moon. We should then create the, probably cycling transports, very large, heavily shielded back and forth between the orbits of Earth and Mars. And we should learn to live off the land. We should be landing on Mars the first time, I believe, to create a permanent presence.

I think the first people there should winter over and return on ships that come out at a subsequent opportunity. And I think that they should always after that have bases there with people on Mars living off the land, enclose the ecology biospheres—a technology, incidentally, which developing will bring great benefits to arid regions here on Earth.

Mr. PERKINS. Yes, and in terms of trying to develop that type of technology, wouldn't it be immensely helpful to have some sort of a Lunar presence as we are trying to develop that?

Dr. PAINE. Yes. I don't believe there's any question about whether it should be the Moon or Mars. If we set up the type of transportation within the inner-solar system, which 21st century technology is going to make possible, we will go to both places and, indeed, we will open up a network of bases around the inner-solar system.

Mr. **Perkins**. Well, my feeling about this has always been, and my goal has always been the colonization of Space. I mean, I make no bones about it.

So, in terms of trying to get there and what attempts that we're going to try to attain that, it always strike me that the problem that we hit with the Moon and the big problem there was it was there and then afterward, we had nothing left. We had the spinoffs from the technology, which was wonderful, but we never really had the idea that we were going to go there as part of an ongoing effort to continue outward into Space.

And it strikes me that that ultimately has got to be almost a stated proposition that we've got to deal with.

Yes, Don.

Mr. **Fuqua**. If I might, Mr. Perkins, say that what Dr. Paine has outlined and one of the reasons that we created the Commission was to take an objective look at where we should go. The Space Shuttle is not an end in itself. It's a building block.

And then whether we go to the Moon or to Mars or how we get there, we use a series of steps, infrastructure as you outlined it.

I just pointed out in my opening statement, in 1958, my good friend and your colleague from Kentucky, Bill Natcher, was on that Committee that——

Mr. **Perkins** Talks about it often?

Mr. **Fuqua** [continuing]. Yes, he did. And they said the preservation of the U.S. leadership in science and technology. That's where we should be going.

They didn't say Mars or the Moon or where. That was something that the experts had to come up with. But, those people on that Committee, chaired by John McCormick, who later became Speaker of the House, Joe Martin, who had been Speaker of the House, and many other distinguished people, only two of them still living—Bill is the only one still serving in Congress that was on that Committee, that Select Committee then.

But, I agree with what has been said, and what you've said. It must be a structure, an infrastructure, that one leads to the other. We don't have an end of the road. This is an unlimited journey that we're talking about pursuing.

Mr. **Perkins**. With the—given the fact that, Don, you've got some knowledge about all. You've been in industry now for a while. Of course, you served here for 20 years. You know the problems of trying to develop long-range goals. You know how NASA works. You know how the system works.

Is it possible, unless we have some sort of general consensus that amazingly occurs, to have a long-term policy that we're able to effectuate?

And if so, how?

Mr. **Fuqua**. Well, I think you hit the nail on the head. That is one of the problems of our system's government. I'm not proposing we change it, but one of the things that we do, and Mr. Packard mentioned it and Dr. Paine, is about international programs. One of the problems we've had in international program is we haven't been a very reliable partner. We come on hot one day and cold the next. And we'd change this year, or OMB would reduce the funds the next, or we've had those type of problems.

Those have to be corrected. We need to set a goal that we are going to achieve and try to go along that road. It needs the support of the President. It needs the leadership of this Committee, the members that serve on here, to try to convince your other colleagues in the Congress and the other body—I understand you can say "Senate" now. You've changed the rules, but—[Laughter.]

But you have to have that in order to. We're dealing not in short-range programs because when they outlined the interstate highway system, which your father was very active in, many other great programs, they didn't stop at the Mississippi River. That was a long-term program. It went all over the United States and opened up areas that had never been opened up to this country. The bridges and many other things that this country has done. Waterways and other things were not short-term. They were long-term goals doing them a step at the time, like the song that Johnny Cash made famous, "One piece at a time."

And as Charlie mentioned, you can't do it all overnight or in one budget year, but it has to be a long program and you lay those steps out and you try to achieve those things as time and resources and so forth, and technology, becomes available.

Mr. PERKINS. Do you think it's good to have—I don't want to take up too much time, but——

Mr. TORRICELLI Don't worry about that.

Mr. PERKINS [continuing]. Do you think it's good to have a focus within that framework like going to Mars within a particular time span? Or having a certain infrastructure before you go? Or just kind of going along as you do and try to make technical advances that are more towards the long-term goal of remaining in Space indefinitely?

Mr. FUQUA. Well, I think you have to—you need goals. Maybe you don't say we go by 1995. Say we try to go in the next 10 years.

Mr. PERKINS. If we're not gone by 1995, Don—I hear——

Mr. FUQUA. Oh, no. Oh, no. [Laughter.]

And, listen, as I mentioned, too, the cost is going to be very, very expensive for a Manned Mission to Mars. We have a pretty full pallet right now for funding. But I still think we need to set those goals. And as resources are available, that we try to achieve them.

You can still work towards those. And I don't even think it's that imperative that you have a specific time that you're going to do it. As long as you have that "That's the goal that we're working toward," and you lay those stones along the way to get there.

Mr. PERKINS. I remember the speech. I was sitting in front of the Capitol when Kennedy gave that speech at Inauguration. And there was an excitement there when he said, "Let's go to the Moon by the end of the decade," though that seemed to generate something in America that created momentum that I'd like to see again. Momentum that, hopefully, we wouldn't just dissipate, as we did.

Mr. FUQUA. Yes.

Mr. PERKINS. But, you know, it seemed that that specific goal did definitely play a part in getting us moving.

Mr. TORRICELLI. Is the gentleman concluded?

Mr. PERKINS. Yes.

Mr. TORRICELLI. Mrs. Morella.

Mrs. **Morella**. Thank you. I certainly couldn't agree more with you in terms of the need for NASA to have goals and the question was posed more long-term kind of funding.

How else can we even launch the Mars Observer Satellite by 1992 if we're not going to be on course with those directives?

And of course I think your statements really do appeal to the American public, if we can just continue to expand it in terms of the patriotism, the excitement of this kind of exploration.

I'm wondering if you see such things as the Super-conducting Super-Collider as an impediment to the Space Station. That's one of the questions I have, if you would care to respond to that.

We just had a hearing this morning on site selection. I'm curious about whether you see this as something that we probably should not put high on a priority list, or whether you see this as competition.

Anybody who wants to answer.

Dr. **Paine**. I guess there's no desire to jump in. I'll jump in where angels fear to tread. [Laughter.]

More from competition. I see them as highly complementary. The Space Program, the Department of Energy's Programs to probe the ultimate structure of matter really all come together. They're a part of the frontier of human knowledge. They're a part of pushing it back with the objective of learning more that, in the future, we have quite a lot of confidence will benefit mankind, although we can't explain right now exactly how this knowledge will be applied.

All we can say is in the past it always has been. We are getting very close to an understanding, we hope, of ultra-fine particle physics, getting down into the basic constituency of the core of the atom and from this, we hope very much that we can get an understanding which will go back to the Big Bang, the entire history of the evolution of the Universe, understand the tremendous energy sources that we see in astrophysics and astronomy.

The difference between the very large-scale that astronomy and NASA looks at and the ultra-fine scale that the Super-Collider will be exploring is very large in scales of orders of magnitude.

But they're all a part and parcel of the same basic problem of understanding the Universe around us.

And as the human intellect gets its mind around these things, in the past, we've always had new energy sources, new devices of various kinds that can benefit mankind.

We're quite certain that that will happen in the future. But it's very hard right now to say what the discoveries the Space Telescope will bring us will be and how those will tie in with the Super-Collider, but I'm sure those two devices are going to have a number of common interfaces.

Mrs. **Morella**. I would feel that that is the case. However, you reach the point where maybe not everything can be done because of financial constraints. I mean, ideally, we would do everything in terms of R&D. And I just wondered if you see this as a problem.

Dr. **Paine**. It's a real problem, and I think the priorities are what this Committee is all about. You have to get your mind around them. But I think, from the standpoint of those two experiments, let's say the astrophysical information that we'll get from the very early Universe when these particles were just coalescing to form atoms and then, after that, coalescing to form stars and super novas which then created heavy elements and threw them out, that's a process we want to understand.

The Super Collider is going to give us a good deal of information about how those basic things went along. And as each of these moves forward, I think you get a better idea year to year as to where the best place to put America's science and technology money is.

There's no easy answer. And it changes constantly.

Mrs. MORELLA. Beautiful political answer. [Laughter.]

Did you want to answer, Mr. Fuqua?

Mr. FUQUA. Well, I've given——

Mrs. MORELLA. It's in the—I hold you in great awe because I understand your institutional memory comes from the experience of chairing the Full Committee. I think that's a great tribute.

Mr. FUQUA. Well, I think that the challenges facing the Committee are certainly very enormous this year. And it's not an either/or Space Station or SSC. They're all very, very important programs. I think the SSC is a very important challenge, particularly in particle physics or high-energy physics, that we haven't had before.

And it's an opportunity not only that of many of the thousands of high-energy physicists that would be depending on this to help them in understanding their work as they proceed.

We have many of the things right now at FERMILab and others that are contributing to this. But this is another step forward. We've solved a lot of those problems at that level.

Here again is another bridge, another stepping stone. And that's why I enjoy being on the outside a little better right now. I don't have to wrestle with some of those very, very difficult and tough questions that you people do that are still elected. You're doing a very fine job.

Mrs. MORELLA. Thank you.

Mr. Torricelli wants to ask a question. Before he does, I just want to point out I understand the President's going to come out with a Personnel Plan with regard to increases. One of the concerns I have is the fact that it may be that what he calls critical areas for pay increases. And I don't know how you feel about that, and I guess we don't have time to discuss it.

But I'd be concerned that certain people are selected and not the whole SES group that are under the——

Mr. FUQUA. I applaud the President for doing that.

Mr. TORRICELLI. I'll applaud him when I see what particular areas he picks. [Laughter.]

I'll talk to him about critical. [Laughter.]

Before we break, let me just briefly, if I could.

As you know, last year, I authored an amendment which was accepted by the Committee, accepted by the House, but lost in conference, to have the President name a National Mars Commission, to approach the Soviets, the Europeans and others not only to set a long-term goal, but also to coordinate all interim activities.

That we identify what technologies are required to get to Mars. The things that each agency might be doing in the various countries complement a common goal. And that we commit ourselves now that an eventual mission will be of international proportions. Begin to define what is required.

Having failed once to get that through the White House of a different Administration does not mean I'm not going to do it again. It's going to be offered assumed adopted by this Congress.

Do any of you have any misgivings about that initiative?

Dr. **Paine**. Well, I've read it with great care and great interest and great approval. I thought it was a wonderful idea and I was sorry that it didn't proceed.

I would only comment that there's another approach that you could also take, and that would be to have President Bush, in naming the new Administrator of NASA, publicly announce that he is directing him to prepare such a plan for review by the end of the year. And that on the basis of the proposal that NASA makes, he will make up his mind as to what long-range position we should take.

That would have the advantage of not being an external plan imposed on NASA, but rather the people who have to carry it out would be the ones who would be——

Mr. **Torricelli**. Of course, that would be my preference, too. But the problem is it hasn't been happening.

Dr. **Paine**. No, and the National Commission on Space had to come in and do some long-range planning because it didn't happen, too.

Mr. **Torricelli**. If George Bush would like to seize the initiative and make such a directive, I would be the happiest man in town. There is not a pride of authorship here, there's a goal to be obtained. And I would be only too glad to see that happen.

Do either of you have any misgivings about such an initiative?

Mr. **Walker**. Mr. Torricelli, I don't have misgivings with regard to the Mars Commission as a piece of proposed legislation or an initiative on the part of the Congress or the Administration except to say that I think that implicitly, the President should be aware and, hopefully, should include in such a statement or the legislation should consider incorporating explicit recognition that NASA has within itself now, a two-year old body, Office of Exploration, which, in fact, has done much of what I think would be considered to be useful and significant groundwork in this regard.

And in addition, I would also recommend from the perspective of the National Space Society that an explicit statement that the Moon should not be disregarded as an opportunity that should be considered within the context of the goal.

Mr. **Torricelli**. I don't think you'll find in this, and Mr. Nelson addressed this before he left, I don't think you'll find in this Committee a disinterest in going, returning to the Moon, only that a case must be made that it is relevant for other long-term goals; that it cannot be going to the Moon for the sake of going to the Moon. It must prove that it has some relevance.

Dr. Paine, two minutes or less before we leave.

The Soviet Space failure, PHOBOS I and II, how serious for the Soviet Program? Does it dramatically change what they're going to be doing in the nineties? And does it reveal something about the programs we didn't otherwise know?

Dr. **Paine**. I don't think it presages any great change. The Soviets have in the past had failures and they accept that and they proceed onward. They have not lost all of their Mars probes.

Now, my colleague, Marsha Smith, reminds me that Mars V was a successful orbiter and did return a great deal of useful information from Mars. Mars I was lost, as you know, because of an instruction that was set up by a human error that was wrong and a software program which should have caught it and didn't. Mars II was lost because of on board inability to point the antenna.

I'm sure both of these can be overcome. I would expect to see the Soviets back at Mars very quickly.

Mr. **Torricelli**. I take it, however, it's going to undermine some international confidence from those who had expensive instruments and experiments on board.

Dr. **Paine**. To some extent. But, at the moment, it's that and our Mars Observer are the only games in town. And Mars Observer's budget has been cut to the point where it isn't much of a game.

Mr. **Torricelli**. Does it show any real basic weakness in Soviet technology in tracking or communication or electronics that—

Dr. **Paine**. Yes. I think it shows that there are problems throughout that area. You and I have been to Moscow, visited the laboratories. I think they are not certainly on a par with NASA.

But, the boldness of undertaking the project we should give them great credit for.

Mr. **Torricelli**. Yes. Thank you each very much. It's been an interesting, enlightening afternoon.

The Committee stands recessed. Thank you.

[Whereupon, at 4:04 p.m., the Subcommittee was recessed.]

1990 NASA AUTHORIZATION

THURSDAY, APRIL 6, 1989

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met at 1:40 p.m. in room 2325, Rayburn House Office Building; Hon. Bill Nelson, chairman, presiding.

Present: Representatives Nelson, Traficant, Perkins, Nagle, Skaggs, Johnston and Packard.

Also present: Dr. William S. Smith, Jr., Staff Director; and Todd R. Schultz.

Mr. Nelson. Good afternoon. Today we are going to meet on NASA's institutional issues, ones that are very important: personnel, facilities, organization. These are perhaps the most important issues that are facing NASA today because they are the very tools by which this nation is going to carry out its space program.

It is particularly poignant to me, coming from East Central Florida where the Kennedy Space Center is resident, we are so dependent upon the excellence of the personnel that carry out the mission of General McCartney there as an operational launching center, that you've got to have those people pretty well motivated and, as he's moving around three orbiters there—to be joined by a fourth—getting them all prepared to launch, you've got to have numbers of people and sufficiently motivated people and sufficiently skilled people to do an increasingly complex task.

When the Space Act was signed in 1958, it created NASA; it set it on a mission; and it has done its job extraordinarily well. And we have had people in NASA, at great personal financial sacrifice, that have stayed with the mission because of the exceptionally exciting success-oriented, exceptionally visionary kind of work that they were doing.

But over those years, NASA has had its growing pains. And so the work force that took us to the moon in Apollo is now on the verge of retirement. The civil service salary structure has stagnated and it has declined in its buying power by 50 percent. Many older research facilities today are in bad need of refurbishment. So these things are boring in or affecting the morale of a team that we cannot afford to have its morale affected, particularly not at this time as we are finally coming back from the throes of disaster and we've got to keep everybody going at 100 percent.

Earlier this year—here's a case in point—the pay raise legislation was defeated overwhelmingly, and it was defeated because of the issues of Members of Congress' own salary increase. But the rest of that bill needs to pass because the salaries attendant to the other civil servants, particularly in high-skilled areas such as NASA, such as the National Science Foundation, such as NIH, the National Institutes of Health, we just simply cannot afford to keep those salaries as low as they are under the present pay scales because the exodus is going to be even more.

The federal procurement policy has had a tremendous effect on NASA managers. The post-employment restrictions, or the "revolving door" restrictions, those are certainly well-intended, but they need to be clarified and translated into specific guidelines or else, come May 15, we are going to have many valued employees that are going to leave NASA because they fear an unfavorable interpretation of that law.

So right now we are working with the Office of Management and Budget to try to see that, on an expedited basis, that such an interpretation is rendered. Here again, because of NASA's unique manpower crisis, this subcommittee has a special interest.

NASA, perhaps as much as any other institution in government, needs to have a clear and worthwhile goal for the space program. Yesterday, in action on a supplemental appropriation request, the members of the Appropriations Committee proposed cutting the fiscal year 1989 funding for the Space Station by $600 million. This subcommittee has worked hard to get the fiscal year 1989 funding for the Space Station released—fiscal year, the present one—get it released by the President.

If we have a $600 million cut—it has come out of subcommittee, it's going to full committee—and if this happens, $600 million out of the $900 million appropriation in this present fiscal year, fiscal year '89, well it's "tube city" for the Space Station. And, of course, that is one of the next major steps as we continue to further expand our horizons and ultimately settle new worlds with humans from Planet Earth.

So, gentlemen, in this rather sobering atmosphere, we welcome you. We welcome Dr. Noel Hinners, who in his many management roles has a greater insight into NASA's institution. He has three of our finest Center Directors: Lieutenant General Forrest McCartney of Kennedy; Dr. Jack Townsend of Goddard; and Mr. Richard Peterson of Langley. We look forward to your testimony.

Temporarily, I am going to turn the chairmanship over to my colleague from Ohio. Two floors down, we have a little minor legislation known as the S&L bailout legislation going on, and I have an amendment before the committee right now which they have held in abeyance so that I could come up and start the committee hearing. So I will be popping back and forth as the afternoon goes on.

But this is an important time for you all to make very clear for the record just what is facing the institution of NASA. So, Dr. Hinners, I appreciate it. And, Mr. Chairman, thank you for taking over.

Mr. TRAFICANT [presiding]. I would just like to say in sitting in—Jim Traficant from Ohio—it might sound unusual to you that I have a Department of Energy markup at two o'clock. I just want to say this before I introduce you, Doctor; that the fellow that just left is perhaps the greatest lobbyist for NASA, and I think that the Congress has given him all due respect.

As a Member, I really appreciate your efforts and I apologize a little bit today. The Congress had an early quit and you probably should have a lot more people here. But I stopped in, even though I had that, because I wanted to assure you that the members of the committee, although they may not be here in total now, those that are in town will probably be coming over, and I think you enjoy a lot more support.

We want to support your programs. We are encouraged by your recovery from the tragedy we had and the type of administrative acumen and guile that are bringing us forward. So we are with you. Infrastructure and some of these programs are not sexy items, but we're going to try and help you with them. So with that, Doctor, welcome and good to hear from you.

STATEMENT OF DR. NOEL W. HINNERS, ASSOCIATE DEPUTY ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, DC, ACCOMPANIED BY LT. GEN. FORREST McCARTNEY, CENTER DIRECTOR, KENNEDY SPACE CENTER; DR. JOHN W. TOWNSEND, JR., DIRECTOR, GODDARD SPACE FLIGHT CENTER; RICHARD PETERSON, CENTER DIRECTOR, LANGLEY RESEARCH CENTER; GEN. WILLIAM McGARVEY, ASSISTANT ASSOCIATE ADMINISTRATOR FOR FACILITIES MANAGEMENT, NASA; DR. HOWARD ROBINS, ASSOCIATE ADMINISTRATOR, OFFICE OF MANAGEMENT, NASA; PAUL ANDERSON, DIRECTOR OF INSTITUTIONAL RESOURCES AND ANALYSIS OFFICE, NASA; AND EDWARD A. FRANKLE, GENERAL COUNSEL, NASA HEADQUARTERS

Dr. HINNERS. Mr. Chairman, thank you.

Members of the committee, you have already been introduced to the Center Directors with me today. Also accompanying me here at the front table: Mr. Howard Robins, our Associate Administrator for Management; General Billie McGarvey heads up our Facilities Operation. You're all familiar with Billie, I think. Then Mr. Paul Anderson heads our Institutional Resources and Analysis.

I will, with your permission, submit the formal statement for the record and summarize some points rather than read from the statement.

Mr. TRAFICANT. Without objection, your written statement will be included in the record of this meeting.

Dr. HINNERS. Thank you.

I did want to take just a minute, Mr. Chairman, to reiterate what we think the institution is in NASA and how that functions and the importance of that institution. It is in our view one of the three legs of our stool for accomplishing the NASA mission, the other legs being our industry partners and, the third leg, the academic community.

We exist solely to support and implement the conduct of the approved space program and aeronautics program for the country. Our people, 23,000 civil servants roughly, in eight centers, are a very dedicated work force of professionals, secretaries, clerks, technicians, scientists, engineers. They are attracted by the challenge of the work. Expanding those frontiers of discovery, understanding human experience and technology is what attracts these people to the Agency and what keeps them. We believe what we are doing is indeed for the good of our country and society at large, and we are proud to be a part of the U.S. Government.

The key to the success of our aeronautics and space program is indeed these people, as Chairman Nelson so adequately pointed out. We are accountable for the success and for any failures in the program, be it in the planning, the designing, or the implementation of our mission. It demands excellence.

You have been hearing for the past several weeks about many of the exciting flight programs: recovery from the Challenger accident, three successful Shuttle flights, fantastic opportunities coming up, Magellan being launched the end of this month, the Galileo mission going out to Jupiter very soon, Space Telescope, our TDRS finally getting up there and operating.

You have heard about future potential programs: the CRAF Cassini missions out to Saturn and comets; the Earth Observing System coming up very soon; the Space Station starting; human exploration beyond Earth orbit. One can indeed get euphoric about the potential of our future.

But is our confidence in our ability to produce for the future in the way we have been accustomed to and used to in the past? Frankly, Mr. Chairman, it's mixed. On the positive side, we believe that the young folks still want to come to NASA because there is an exciting program and they believe that NASA is a good place to work. Our scientists and engineers, our new ones, are extremely talented. Most of us would say they are more talented at this stage in their careers than we were when we entered NASA. That is a very good sign.

On the down side, though, there are some trends that we worry about, creeping degradation of our capability. It rapidly becomes an issue of human and other resources. On the human resources side, we fully believe that our total work force size for today's program is under-scoped; that rather than the 22,500 that we started with at the start of '89, we really should be looking at a work force of about 25,000 civil servants, or a delta of almost 3,000. This shortage is experienced largely in our engineering work force, but also some of our support staff, procurement people, people who can oversee the construction of our facilities.

This has been brought about by, number one, the Shuttle recovery, which meant that a lot of our people didn't roll off into other programs; the start of the Space Station; backlog of flight programs that are now awaiting launch; increased complexity; and, sad to say, there is an increasing bureaucracy that has a lot of our people doing what some of us would consider nonproductive work—reviews and reports that we don't see the benefit from, very frankly.

We're not doing some work that we should be doing. For example, our work on early design reviews is not going forth at the pace which it should. And that is where you build quality into your program, in the design phase, rather than trying to inspect it in after things are built or in the process of being built.

We have, we believe, an unhealthy reliance on our contractor work force at this point to do many things which ought to be government work. Now, some support contract is necessary and actually is good. There are things that we don't need civil servants to do and it is good to have contractors do that. Some it is not.

We have too many contractors, for example we believe, doing some of our basic in-house engineering rather than civil servants. As NASA has evolved, as I mentioned, the Shuttle Recovery, Space Station, we have been putting more and more people on our program management. What we call our core capability has been decreasing. This is really our in-house basic engineering scientific staff. We have been trying to augment that and indeed have asked OPM for the last two years for augmentation of our work force.

OPM has responded positively to a degree and given us part of our request. Of the 3,000 or so that I said I think we needed, we have about 1,200 that come in, you might say, a clean form. Mixed in with that, though, there is a challenge grant, if you will, somewhat like the PBS solicitations; that for each position we contract out, we can both maintain that and convert it into an engineer, and also augment our civil service with a bonus civil service position.

We are not going to be able, in all likelihood, to meet the OMB target for contracting out. We have done an assessment, and of the 668 target, we believe we will be lucky to get 400 over a two-year period, or a three-year period rather, instead of that 668 in two years. This is a result of the fact that NASA has contracted out significantly over the last decade or decade and a half. The proportion of our work force has gone from 45 percent engineers and scientists to 54 percent today, even as we have decreased our work force.

What that has meant is we have taken technicians, some of our professional help, and replaced them with engineers and done much more contracting on a one-by-one or group basis on occasion. We have gone about as far as we can in that, and are sincerely convinced that we cannot do much more; that it would be abrogating government responsibility to significantly increase the amount of contracting we do.

Regardless, we now have an authorization for 24,000 people, but we do not have the budget this year to support the authorized level of work force.

Let me turn now to recruitment and retention. We have two problems which you've heard about. One is our entry level. We are increasingly becoming noncompetitive in our ability to attract beginning engineers. Now, we are still getting good people but we are increasingly not getting some of the best. We are talking about differences of $6,000 to $10,000 for a starting engineer with a bachelor's degree.

In our middle range, where we have as you know a gap in our numbers, $35,000 to $45,000 range, we are noncompetitive with industry in being able to attract some new talent into the Agency.

The other problem is at our top level. Chairman Nelson referred to that previously in reference to the pay raise. Indeed, as an example, in looking for an Associate Administrator for Aeronautics and Space Technology, we did want to look in industry to see if there was somebody there who would be a candidate. Of five people we talked to, we got five turndowns. So we are just totally noncompetitive when it comes to attracting people with experience into the government.

Some of this is indeed occasioned by the fact that we do want to augment, on occasion, our civil service work force with new talent from the industry. We are facing a wave of retirement in the next five years. We are starting to see the front end of that wave, and have been for about two years.

Our age distribution is skewed. About 30 percent of our work force now is under 35, and that indeed is good. We have a new crop coming along and need to keep that crop growing. Thirty-five to forty-five, we are at 20 percent, which is lower than it ought to be. Then greater than 45 years old is 50 percent of our work force, and that's the part that in this next five years is going to be largely disappearing.

We would like to hold on to some significant fraction of that until we are able to build up that younger age group in our middle management. The pay raise would have done much to help us hold on to those folks. A pay raise at least would have meant another three years for many, with the high three of the civil service retirement system.

As a definite example of the problem we're facing—and it is exacerbated here at Headquarters and at our Reston Space Station Office—our Reston Space Station Office recently made 25 offers to NASA internal people to come work at the Headquarters—27 offers, rather. Twenty-five turned the offer down. These are internal NASA people who cannot afford the move to the Washington area. Trying to get people from Huntsville or Houston or Florida, which are much lower-priced real estate areas, and Houston is a depressed housing market right now, these people cannot afford to make that move and make the financial sacrifice it would entail coming to this area. There are, I think, some things we can do about that. We will solicit your help on that in the future.

Some of the solutions we are looking at, though, include working with the Congress and the Administration to see what we can do to revive the pay raise activity. I will talk more about that later. I think we need to look into the possibility of having incentives for people to move. Recently, for example, the FBI had to put incentives to get agents to move to the New York area. We may need to think of the same type of thing to encourage technical people to move to our Headquarters operations here in Washington.

We are continuing to investigate work with OPM on an alternative personnel system, to set up a pay band structure which would increase our ability to attract people into the entry levels.

On another note, the distant future, you are all aware, have heard about the country's problems on insufficient scientists and engineers in the future, regardless of whether they work for NASA or not. We see that, too, as a major problem and are beefing up our education programs down in the grade schools so that we help and use the space program as a very positive incentive for kids to get into science and engineering fields.

That fits in very much, too, with some of our equal opportunity work. We have made good progress this last year in women and minorities in our work force, both our scientific/technical work force and our professional/administrative work force. But we realize that there is this long-term problem and that we must help the country in meeting its supply of scientists and engineers.

In our budget, our travel is also inadequate to accomplish our mission. We are not sending sufficient people to our plant representation, to monitor our contractors. We are not attending sufficient technical meetings with our engineers and scientists. We are not doing sufficient design reviews in the contractors' plants. We are trying to use such things as video conferencing to help this problem.

We do use our administrative aircraft to help us get places and help alleviate pressures on our travel budget. But, more than that, it is a conservation of our management's time and is a very good investment.

On the operation of our installation we have particular pressure this year, as we did last. A large part of our budget, about 60 percent, is really fixed. That's with our salary dollars. So any flexibility and any impacts on our R&PM budget really come out of what we call the operation of the installation.

This last year, in fiscal 1989, after our budget was submitted, we took an additional effective $100 million reduction in our operations of our facilities. That came by with a $60 million direct cut and also with an absorption of the pay raise and the health benefits increase. Now, we were able to make up some of that by transferring from our construction of facilities in 1989 into our operation facilities and our personnel. But that just caused a problem in another part of our budget. It meant that some of our facilities which were high priority were not funded. And when we went into the 1990 budget, we put in an amendment to OMB to get those facilities back, but that proposal was turned down.

An additional problem came from something we called appropriation realignment. You will all recall possibly that about two years ago, we had some restructuring between our R&D budget and our Research and Program Management budget. And indeed it was a warranted change. We had over the years been using Research and Development money to support the institution. That came about because over the years we had artificially kept down the real cost of managing the NASA program, but with the realignment we understand that. But it has had an impact because using the R&D, even though maybe it wasn't right, gave us the flexibility that when we hit a problem, when we didn't have enough R&PM funding, we had a place to go to. That flexibility is totally gone now.

So, working with you, we are hoping that in this next year, number one, we can avoid any further cuts in our R&PM budget and also work with you to structure our R&PM budgets in the outyears so they are really requirement-based. I say that because frequently we assume that last year's plus inflation takes care of it. It doesn't in this R&PM budget.

As our program goes up, as we're doing new program, we must also increase the kind of institutional support we give those programs, whether it be in facilities, in numbers of people, or in the equipment, modernizing our laboratories.

That brings me to the CoF Program. You are familiar, I know you have had hearings on parts of the Construction of Facilities Program, but it too is a very important part of our overall institutional capability as well as our support for programs. We have about a $14 billion facilities base in NASA. That's the replacement value of the Center activities, including the Jet Propulsion Laboratory.

Normally, the industry and the NRC Report on Facilities say one should be putting about 3 percent of your replacement value into maintenance. We are putting less than a percent into our facilities maintenance, and there is a tremendous "bow wave" out there that is catching up with us very rapidly. We are continuing to try to increase that portion of the budget, and we are grateful for the support this committee has given us in the past in trying to catch up with some of that bow wave. We realize we will never get totally there, but we are at the point where a lack of upkeep of this tremendous institutional base is going to cause us an increasing problem and more cost when parts of it actually physically do breakdown.

Our budget request in facilities does continue the program we started two years ago for the very important revitalization of the Wind Tunnels at Langley, Lewis, and Ames, a very important national capability. The discrete program, as we call it, is composed of essential institutional facilities for our Research function, our engineering function, but also of course for the very direct program support. Again, I know you are familiar with the specific Space Station requirements in the facilities budget this year.

Our environmental part of the program we started two years ago at $30 million, and we thought at the time that would be a three to four-year, maybe five-year program. It is very clear that from what we are finding in our environmental cleanup, that that is likely to be an ongoing program for quite some time at that level, with possibly a slight increase.

I want to say just a few words now, wrapping up here, on our planning activity. I know this committee has been very interested in how we're doing planning internally in the Agency. We like to break that down into three parts: strategic planning, whereby we set the overall Agency vision, direction, major goals, and really set the structure for the development of specific program goals and objectives. That I think has been going very well recently. We recently set up an organization headed by Richard Reeves, an Office of Planning, reporting to me, to put a little bit more formality into our overall planning process and to be sure that we are becoming product-oriented.

We have seen real progress on that this year and I think the committee all has copies now of what we call the "Agenda for Tomorrow," which is our top-level planning document. This will be updated this summer to incorporate some of the recent changes, including some of the new emphasis on the human exploration of the solar system.

Our next level of planning we call the long-range planning. That is really the guts of the detailed program planning on about a five-year time scale. We recently have again published our 1989 long-range program plan where you can see very clearly the detailed thinking of all of our programs, our aeronautics, our space transportation, our science, our advanced technology, and how those programs fit together.

There is one piece still lacking from this which we will have in our next version, and that's the institutional part. We are trying very much now to get our institutional planning on as firm a basis and grounds as our program planning, so that when we propose to the Congress, to the Administration, a new program such as Space Station or Shuttle C in the future, or an EOS, we at the same time are able to tell you what the institutional impact and resource requirement for that program is.

Strategic planning is going ahead full bore at our Centers and in our Program Offices. I think again you are familiar with Dr. Fisk's "Science Strategic Planning." The most recent one I've received from the Centers is from Marshall Space Flight Center from J.R. Thompson, "Reflection on '88: A View Towards '89." So it is progressing and I think it's in quite good shape. Not perfect, but we're working towards that.

The one thing about the planning is that one can, if you're not careful, overdo it and think you're making real progress. What I am saying there is that while we're doing a lot more planning, and I think getting a better integration of our program plans, the plans are only as good as our ability to get the resources to conduct those programs with excellence.

Those plans are indeed good and you will see some of that in the Capital Development Plan which you have asked for, which we anticipate OMB will release in the near future. We believe, though, that regardless of this planning activity, we must concentrate on this year's budget. The budget is tight all around. You've heard that, I know, from every program person. Dr. Fletcher mentioned that. He is absolutely correct. Our program, our institutional budget is equally tight.

My assessment is that if the Agency takes a major cut in its institutional capability, it has got to face up to saying we must take some program cut to accompany that. We are very close, if not there, at the point where our Centers which must implement these programs are saying, don't give me any more work unless you give me the resources to accomplish it. I can't do it with the competence and the ability that you expect of me.

We remain, Mr. Chairman, an enthusiastic bunch. We always look forward to challenges, but we're going to need one hell of a help in meeting this challenge this year.

Thank you very much.

[The prepared statement of Dr. Hinners follows:]

Statement of

Dr. Noel W. Hinners
Associate Deputy Administrator

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science, Space and Technology

United States House of Representatives

Mr. Chairman and Members of the Subcommittee:

I welcome the opportunity to speak with you about the NASA Institution, the foundation upon which the Agency programs are built. With me today are Howard Robins, Associate Administrator for Management, Billie McGarvey, Assistant Associate Administrator for Facilities Management, Paul Anderson, Director, Institutional Resources and Analysis, and two of our Center Directors--Forrest McCartney from the Cape, and John Klineberg from Lewis. I have asked these representative Center Directors to be here this year to respond directly to issues or questions in order to provide you additional insight into the criticality of the Institution and the tightness of the resources devoted to it.

Because the institutional aspects of NASA are not as well known as its programs, I'll begin with a definition of "Institution" and of my responsibilities as Associate Deputy Administrator. I will bring you up to date on Agency planning, give you a progress report on key issues, review the major institutional needs and issues that we are facing now or in the near future, and discuss the specific FY 1990 R&PM and CoF budget requests which enable the NASA Institution to function.

I describe the NASA Institution as the foundation for our programs. Like the foundation of a building, it is the least visible part; but its importance to the viability of the structure make it absolutely necessary. In that sense, the NASA Institution exists for only one reason: to successfully implement the Nation's aeronautics and space goals and programs.

The NASA Institution is the aggregate of those functions and resources involved in the development, utilization and maintenance of the Agency's in-house technical and managerial capability. This includes our people, facilities and equipment, and the systems necessary to sustain and manage them.

Our objectives for the Institution are: to provide the essential civil service staff, possessing required technical and management skills, to conduct the full range of NASA programs; to support the programs with the necessary facilities--from offices to wind tunnels to launch pads; and to provide technical and administrative support. We strive to accomplish these objectives effectively and efficiently as we implement NASA's approved technical programs.

This past year we restructured the senior management positions of the agency to place greater emphasis on the NASA Institution. My job, as the Associate Deputy Administrator, is focused on providing agencywide leadership in planning, facilities, equipment, funding, and staffing of the Institution, an area that requires increased attention.

PLANNING

NASA has given increased attention to planning. NASA's planning process is extensive, and is designed to produce a coherent statement of agency vision, long-range goals, near-term objectives, and the strategies for achieving them.

Guided by top-level planning and agency priorities, our process strives to achieve an integration of individual program and center plans. Specifically, our planning process is designed to ensure that the results are consistent with our vision, the National Aeronautics and Space Act, the Presidential Directive on National Space Policy, and the needs of our user communities.

In recognition of a variety of political and technological events, NASA instituted a new strategic planning cycle last August. One of these events, for example, was the signing of the National Space Policy in February 1988. For the first time, we now have a long-range goal of expanding human presence and activity beyond Earth orbit into the solar system. Other factors included the progress of Space Station Freedom, the studies accomplished by the Office of Exploration, and the changes within the Agency since the Challenger accident.

We started this new planning cycle with an assessment of the environment in which we operate. This included a review of the current National Space Policy; NASA's charter, the Space Act; the guidelines of the FY 1989 Authorization Act; and studies by the National Commission on Space, the Ride Committee, the American Institute of Aeronautics and Astronautics, and others.

Also, we have put in place a statement, or vision, that defines NASA's long-term, strategic direction. This vision provides the foundation for the Agency's strategic planning.

Furthermore, we are developing a 5-year Capital Development Plan, as directed in the FY 1989 NASA Authorization Bill. We expect that this Capital Development Plan will enhance our overall planning effort.

Planning at NASA is recognized as a continuous process, with many activities taking place concurrently and affecting each other. To more readily work the process and for discussion purposes; we have divided our planning into three phases; strategic planning, long-range planning, and near-term planning in practice, these three phases are not this clearly distinct from each other.

Appendix I discusses in more detail our planning activities and contains our recently developed NASA vision. However, the key point I wish to make is: the greatest value of the planning process is in the communication and decision making inherent to the process itself, more so than from the act of publishing a final plan.

PROGRESS REPORT

Last year the NASA Institutional budget, as funded by the R&PM appropriation, was reduced during the Congressional deliberation process by $60 million. In addition, we were required to fully absorb an additional $40 million for the FY 1989 pay raises and increases due to health insurance rate changes. This reduction is a severe challenge to the NASA Institution, particularly after the impact of the FY 1988 reduction of over $100 million. The resulting program as formulated by the management of NASA for FY 1989, provides for almost no growth in critical development areas. In order to achieve the targeted budget levels, it was necessary to significantly reduce the amount of custodial and maintenance support provided to our aging facilities and defer acquisition of administrative data processing and other equipment systems, reduce technical libraries and education support, eat into inventories, etc. This approach, although effective to satisfy the short-term budgetary shortfall, will not lead to desireable long-term effects for the Agency and is a course we ought not to follow for FY 1990.

In FY 1990, we must regain that progress and expand our efforts to position ourselves to meet the challenges set out in the National Space Policy and to implement our strategic direction. Towards this end, we must recognize that the NASA Institution is a vital ingredient in the preservation of U.S. leadership in space and aeronautics. Such leadership requires high-quality people and world-class facilities for research, development, and operations.

We believe that to achieve your full support overall understanding of the critical role of the Institution must be more clearly communicated. The Institution does much more than provide accountants, personnel specialists, procurement officials, etc., and housekeeping ingredients, needed to support NASA's programs. True, it includes these necessary functions, but also, it consists of the scientists, engineers, and technicians important to research and to the design, the development, and the execution of programs. The Institution is the laboratories, wind tunnels, the launch pads, the control rooms, and similar facilities needed to conduct a program. The Institution is the equipment and the logistics that enable the work to take place. And, the Institution collectively provides the technical knowledge and the corporate capability necessary to accomplish the significant amount of work we do with the private and academic sectors throughout the nation.

Staffing

During the summer of 1988, NASA completed an in-depth review of its workforce requirements. The results of the study indicated that based to a large degree on Shuttle, Space Station Freedom, science program needs, and to a lesser extent on core research and technology capability requirements, NASA would need an increase to its current workforce. After discussions with OMB relative to the results of the workforce review, OMB agreed that NASA's Full-Time Equivalent (FTE) authorized ceilings be increased in FY 1989 to 23,734 and to 24,007 in FY 1990, an overall increase of 1,582 from the FY 1988 authorized ceiling.

This year we are asking for funding for the majority of these civil service employees. Such support would bring our staff level to 23,700 FTE for FY 1990, exclusive of FTE assigned to the Office of Inspector General, now carried in their own budget. As part of achieving this increased ceiling, NASA must convert selective positions to the private sector. This presents a real challenge. As a result of NASA's historical reliance on the private sector we are approaching a situation where 90 percent of our funded activities will be executed by contractors. There is little room for additional contracting; however, we are striving to identify 668 positions that can be converted in fiscal years 1989 and 1990.

Personnel Retention Problems

A growing concern we need to bring to your attention is our ability to maintain a first-rate workforce. Each year we are finding it increasingly more difficult to attract and retain a high quality staff. The inability to make timely job offers, the limitations of the civil service classification system, and less than competitive pay for many disciplines are examples of problems with the current system. These problems are exacerbated by NASA's aging workforce, a result of the downturn in NASA's employment following the Apollo missions to the moon. Over 50 percent of our most experienced people are eligible for retirement within the next 5 years. Due to past hiring limitations, we have too few mid-level people in position to replace those retiring, and we have little ability to recruit mid-level and senior replacements in a very competitive market for such talent. In fact, as you know, a major limiting factor is the current pay schedules.

We believe that many of those now eligible to retire will do so in direct response to the defeat of the pay raise proposal. We believe replacement efforts will be frustrated by the growing differential in pay between the civil service and the private sector. Several examples might help illustrate the point. Based on a December 1987 study, a NASA center director was paid at a rate of $77,500 per year (and only $80,700 today), considerably lower than the $111,333 to $156,150 compensation package average then paid in the private sector for similar positions. The SES position of Director, Microgravity Sciences Division, has been vacant since 1986 despite repeated attempts to fill the position. We have been unable to fill the position at the skill level we require for the maximum salary we can offer, SES-6, $80,700. Most recently illustrative is that three key senior executives were lost to private industry in 1988 at salaries double, or more than double, their SES pay.

Such a situation creates anxiety in our managers. NASA civil servants are dedicated, and the strength of NASA's programs has always enabled us to recruit and retain highly skilled people at somewhat lower salaries. At some point, however, the differential between public and private pay becomes too great, and these dedicated, experienced people will make decisions for the benefit of themselves and their families. We believe that in order for NASA to remain an organization of excellence, a new mechanism must be found to solve this basic problem of adequate compensation.

Alternative Personnel System

For the past 6 years, NASA has investigated creative mechanisms for improving personnel management. The Office of Personnel Management (OPM) and the Congress have been sympathetic to our needs. Last year, working with this Committee, our efforts focused on an Alternative Personnel System which would improve compensation practices, simplify personnel procedures, and provide managers with more efficient and effective tools with which to manage. Last year's proposal for the development of a modern personnel system, made in conjunction with the Department of Defense did not result in approved legislation; we are reexamining where we go with Agencywide efforts this year.

In parallel to Agencywide efforts, OPM has recently approved a concept for a demonstration project within NASA under the auspices of the Civil Service Reform Act of 1978. Although this demonstration project can encompass only one or two centers (since it is by law limited to a population of 5,000 employees), if implemented, it will serve as a base on which to test an alternative personnel system for possible future use agencywide.

Equal Opportunity Program Status

NASA continues to implement an Equal Opportunity Program which carries out the letter and the intent of the relevant civil rights laws and regulations, and which aims to accomplish its technical missions and programs with an effective workforce that is integrated at all levels with minorities, women, and individuals with disabilities.

We have made progress increasing minority and female representation throughout the NASA workforce in FY 1988. As of September 30, 1988, minorities and women comprised nearly 36 percent of NASA's total permanent workforce; 20 percent of the scientists and engineers; 19 percent of its astronaut corps; 12 percent of its managers and supervisors; and 7 percent of its Senior Executive Service members. Management commitment to enhancing such representation across-the-board is reflected in a wide variety of affirmative action strategies. Such activities include special recruiting efforts; training, development, and career advancement of on-board staff; and developing a resource pool of talented engineers and scientists through efforts with the educational community. Further details of this past year's accomplishments are contained in Appendix 2.

RESEARCH AND PROGRAM MANAGEMENT

Our FY 1990 Research and Program Management (R&PM) budget request is for $2,032,200,000; which consists of $1,222,040,000 for Personnel and Related Costs, $50,957,000 for Travel, and $759,203,00 for Operation of the Installation. The Operation of the Installation category is subdivided into $305,486,000 for Facility Services, $195,671,000 for Technical Services, and $258,064,000 for Management and Operations. This funding will support a permanent and temporary civil service staff of 23,700 full-time equivalents who provide the technical and management skills to conduct NASA's programs. The amount requested for travel is the minimum funding necessary to accomplish our launch schedule, contractor oversight, technical coordination, professional proficiency, and management coordination and control. The facilities services funding request provides for essential base maintenance of the facilities needed to support the R&D programs and the utility costs for operating the facilities. The technical services funding category of our R&PM request provides the resources necessary to accomplish the performance and management of research, technology and test activities, and the planning, management, and support of contractor R&D activities necessary to meet the program requirements of our aeronautical and space research. The management and operations request provides for communications costs, medical services, transportation of equipment and material, and purchases of supplies and general purpose equipment.

Mr. Chairman, this is a very conservative request, one which has been extensively reviewed and refined prior to submittal.

The R&PM request reflects, as a top priority, the strengthening of NASA's personnel capability through the staffing augmentation which we expect will revitalize the Agency and assure the ability to carry out the approved programs. Other efforts, which we believe are necessary for full revitalization of the Institution, particularly in terms of current automation capabilities, full performance maintenance, and replacement of aging aircraft, vehicles, and equipment, have once more been stretched out or deferred. I want to assure you that the R&PM activities being requested here are critical to the healthy operation and effectiveness of NASA as a viable institution and that the request has been constrained such that it includes no flexibility. Without full Congressional support for this request, we question how well we can accomplish the program goals you have supported and authorized.

Personnel and Related Costs

This account includes salaries and benefits, the Government's contribution to personnel benefits, cost of the Federal Employees Retirement System (FERS) and the Civil Service Retirement System (CSRS), and for personnel detailed to NASA. It also provides for moving expenses, recruiting, personnel investigation services, and training.

As I have said, current budget levels allow NASA to partially meet OMB approved higher ceilings, thus this budget request of $1,222,040,000 is predicated on NASA's ability to fund FTE levels of 23,150 in FY 1989 and 23,700 in FY 1990, excluding those assigned to the NASA Office of Inspector General.

Travel

The largest requirement for travel, nearly 70 percent, is for direction, coordination, and management of program activities. The complexity of the programs and the geographical distribution of NASA contractors and installations require that NASA managers, scientists, and engineers travel to effectively carry out highly interactive programs. Further, the amount of travel required for flight projects is significant, and increasing, as it is a direct function corresponding to the number of systems, subsystems, design reviews, and the number and complexity of launches, their payloads, and associated ground operations. Other travel requirements are for travel to scientific and technical meetings without which the technical competence of the staff cannot be maintained. Another very critical category is management and operations travel, which is necessary to accomplish the overview of management matters, review the status of programs, accomplish permanent changes of assignment, and conduct functional management activities related to personnel, financial management, internal controls, logistics, and procurement.

Operation of the Installation

The Operation of Installation account provides a broad range of services, supplies, and equipment to operate our centers. These are divided into three major functional areas: Facilities Services, for maintaining and repairing institutional facilities and equipment, and providing custodial services and utilities; Technical Services, that provide automatic data processing for management activities, and the cost of educational and informational programs and technical shops; and Management and Operations Services that provide administrative communications, printing, transportation, medical, supply, and related services.

As a result of the FY 1988 Appropriation Realignment, major pieces of the NASA technical program that previously had been funded by either the Research and Development or the Space Flight, Control and Data Communications appropriation are now funded only by the R&PM appropriation. An example of such an inclusion is security services. To be more specific, at Kennedy Space Center, R&PM funds are now used to provide for control of access into flight hardware processing areas, protection of flight hardware by surveillance within facilities, as well as special test and launch requirements. Previously, R&PM funds would only have been used for basic security activities such as outer perimeter post protection, badging, investigations, etc. Similarly, all printing is now funded by the R&PM appropriation. This means that all program documentation, including such items as shuttle maintenance instructions and schedules, flight readiness firing schedules, and general operations instructions are now R&PM funded. The net result of appropriation realignment is that the R&PM funding requirements are more directly driven by program requirements. Those have been substantially increasing and have frequent unforseen increases during the year with resultant negative impacts on our R&PM budget.

The deteriorating condition of our institutional facilities is an increasing concern. Constrained budgets have forced the deferral of many essential maintenance activities over the years, and this has been compounded by block obsolescence due to many facilities constructed in the 1960's reaching their normal 25-year service life for such critical needs as roofs, pavements, and mechanical equipment. An Agencywide maintenance needs assessment was recently completed; as a result, we will require a significant increase in our future budget requests for institutional facilities maintenance.

As you will note in the budget submission, the decrease from the FY 1989 Budget Estimate to the FY 1989 Current Estimate reflects reductions in the planned level of contractor support and deferrals of ADP purchases and other equipment purchases due to budget reductions. The increase from the FY 1989 Current to the FY 1990 Estimate is restoration of a small number of deferred purchases and the inclusion of essential upgrades to the financial systems as well as support required for the planned larger on-site workforce. However, much effort in institutional revitalization is still required.

NASA Headquarters

I would like to turn briefly from the Agency perspective to the subject of NASA Headquarters. First, I wish to express our appreciation for your support in helping work toward a new consolidated facility for the Headquarters. The new facility will greatly improve our work environment and lead to increased morale of our Headquarters staff. GSA has issued the Solicitation for Offers, and we anticipate that they will receive responses with specific offers by late April. After evaluation and price negotiation, we believe GSA will award a lease for us by the end of November this year. Our actual move, of course, will depend on the arrangements and location contracted for by GSA, but we anticipate late 1990 to early 1991.

A point I would like to make concerning the size of Headquarters is that more than one out of every six of our 1,808 full-time permanent employees of NASA Headquarters works outside Washington, DC. These duty locations include the Space Station Freedom Level II Program Office personnel at Reston, Virginia, and the field installations responsible for elements of the space shuttle program, the NASA Resident Office in Pasadena, California, Inspector General personnel at all field installations of the agency, and international representatives in Europe and Australia. Over three hundred Headquarters employees are performing important tasks outside the beltway.

If we discount the presence of new, large Headquarters Level II work activities such as the Office of Space Station and the growth of the Inspector General's staff, the size of NASA Headquarters approximates its size of the early 1980's and is smaller than the Headquarters of the late 1970's which managed a smaller program.

Contrary to some perceptions, NASA Headquarters has not grown at the expense of the muscle and sinew of the field installations. I am in the midst of an extensive review of the Headquarters workforce; I assure you that vital work, critical to the program needs of NASA, is performed at all 16 duty stations that define NASA Headquarters. A number of our functions are genuinely understaffed. We will strive to correct these shortages through judicious augmentation of Headquarters civil servant staffing.

R&PM Summary

In summary, approximately 60 percent of the requested R&PM funding is required to provide the salaries and related costs of the NASA civil service workforce. Two and one half percent is for travel, critical to manage successfully the Agency's in-house and contracted programs. The remaining amount, 36.5 percent, provides the necessary support for maintaining and utilizing our research, test and operational facilities, pays utilities costs, and provides for the related purchase of goods and services necessary to operate efficiently and effectively the NASA installations and to accomplish NASA's approved programs.

CONSTRUCTION OF FACILITIES

The NASA Construction of Facilities (CoF) Budget request for FY 1990 is $341.8 million. The "bow wave" of deferred Space Station Freedom ground facilities projects has now caught up with the most vital developmental and operational requirements of the program. They all need to be funded now to preclude significant delays in the Space Station Freedom program. Consequently, the funds requested for FY 1990 provide for critical facilities requirements for Space Station Freedom and space flight programs; construction of new facilities needed to support science, space technology and aeronautical research; and continuation of the multi-year effort to restore and modernize NASA's aeronautical research and development facilities. Also included in our request are funds to continue the ongoing repair, rehabilitation and modification of other facilities; funds to maintain, upgrade and improve the usefulness of the NASA physical plant; funds to accomplish the minor construction of new facilities; funds to conduct facility planning and design activities; and funds to continue our environmental compliance and restoration program.

In addition to the basic request of $341.8 million, the possibility of private sector investment is being explored for three discrete projects. These projects are the Space Station Processing Facility at the Kennedy Space Center, the Neutral Buoyancy Laboratory at the Johnson Space Center, and the Observational Instruments Laboratory at the Jet Propulsion Laboratory. These projects are believed to be potentially suitable for processing, developing, or manufacturing commercial products, as well as providing direct support to critical NASA programs and operations. NASA has also provided for the possible selection of a private investment option for the Advanced Solid Rocket Motor (ASRM) production and test facility. The ASRM contractor selection process is underway, and will include evaluation of proposals for private investment in the production and test facility to be built at Yellow Creek, Mississippi, as well as proposals based on use of a Government funded facility. All four facilities are key operational and development facilities with an equivalent budget requirement of $147 million, and if we are not successful in obtaining private sector participation and financing, alternative means for funding the requirements will have to be identified.

This year's budget continues our strong emphasis on Restoration and Modernization Projects. We are requesting $106.6 million, which includes $64.2 million for the second year of a five year Aeronautical Facilities Revitalization Program, to restore and modernize facilities which are key to maintaining U.S. preeminence in aeronautics.

Except for the projects proposed for private sector investment, the FY 1990 CoF request is in the same format as prior year requests, with $211.5 million requested for discrete facility projects, $74 million for minor projects, $26.3 million for planning and design, and $30 million for environmental compliance and restoration activities.

Space Station Facilities

The FY 1990 facilities requirements for Space Station include seven discrete projects that are critical for necessary development and testing activities. Five of the projects were requested in FY 1988 and FY 1989 but were deleted by Congress, without prejudice. Five of the Space Station Freedom projects are included in the basic budget request. As I have mentioned, the Space Station Processing Facility at Kennedy Space Center and the Neutral Buoyancy Laboratory at Johnson Space Center are being proposed for private sector investment. All seven projects are critical requirements for the timely development and validation of Space Station Freedom hardware and design.

An addition to the Space Systems Automation and Integration Facility at Johnson Space Center is needed to test and validate different methods for on-orbit assembly of major structural elements and to conduct proof-of-concept evaluations and certification testing. The addition to the Mission Control Center at Johnson Space Center is required to provide ground support of on-orbit assembly and continuing operations of Space Station Freedom. This addition will provide the operations and associated equipment areas required for 24-hour support of the Space Station Freedom.

Construction of an addition to the Simulator/Training Facility at Johnson Space Center is necessary to accommodate the crew trainers and simulators needed for the Freedom unique systems, operations, and crew stations. Adequate training of space station flight crews and ground-controllers requires the use of this facility.

The project to modify Chambers A and B in the Space Environment Simulation Laboratory for expanded solar simulation is required to provide high-fidelity solar simulation test environments for large, complex, and thermally sensitive structural parts of the Space Station Freedom. The Modifications to the Process Technology Facility Project at Marshall Space Flight Center is needed to develop on-orbit repair processes, test different sealing materials, support repair hardware development, and test prototypes and engineering models.

Construction of the Space Station Freedom Processing Facility at the Kennedy Space Center is required to permit assembly, servicing, testing and check-out of the Space Station Freedom elements, systems, and payloads prior to launch. This is an in-line operations capability that must be provided in this budget timeframe. The Neutral Buoyancy Lab at the Johnson Space Center is required for validating and checking out Extra Vehicular Activity (EVA) procedures and concepts for station assembly and servicing. Based upon our experience with Skylab and Shuttle, we believe that the ability to demonstrate and practice EVA capabilities on a large scale is crucial to assembly and support of the station.

Space Flight Facilities

All but two of the eight projects in this category are needed to restore and modernize basic facilities and support systems. These include the replacement of Cooling Towers at Launch Complex 39 Utility Annex, replacement of Launch Complex 39 Pad A Chillers and Controls, replacement of Roofs at Launch Complex 39, and replacement of the Vehicle Assembly Building Air Handling Units at the Kennedy Space Center. Two projects at Stennis Space Center will replace 25-year-old High-Pressure Gas Storage Vessels that have reached the end of their service life and modify the Engine Test Complex High Pressure Industrial Water System to restore capability lost due to declining water pressure in existing aquifers.

The budget request also provides a second increment of funding for construction of security protection for the space shuttle and related facilities that have been designated as vital national resources at Kennedy Space Center, Dryden Flight Research Facility, Stennis Space Center, and the Michoud Assembly Facility.

The largest Space Flight Program facility project upgrades the existing Orbiter Modification and Refurbishment Facility (OMRF) at Kennedy Space Center to a full-up Orbiter Processing Facility (OPF) #3. Post-Challenger accident test and checkout requirements have resulted in increased OPF processing times for added safety, which in turn reduces the annual turnaround capacity per high bay. With the delivery of the replacement (fourth) orbiter to Kennedy Space Center in 1991, requirements for extended use of an OPF bay for initial checkout and activation, and later requirements to support steady-state operations of a four-orbiter fleet, necessitates three full-up orbiter processing facilities. This FY 1990 project includes safing and deservicing modifications, provides an orbiter access system, cranes, and additional orbiter processing equipment and support systems to achieve a full-up OPF bay #3 capability. Maximum use is being made of components, work stands, and equipment from deactivated shuttle facilities at Vandenberg Air Force Base, California.

Space Science and Applications

Four projects required for Space Science and Applications Program activities are included in this request. The first is a basic item critically needed to modernize the South Utility Systems at the Jet Propulsion Laboratory. The project is to construct a consolidated utility corridor. Two projects at Goddard Space Flight Center are required to provide essential program support activities. One is an addition to an existing building to provide a Data Operations Facility for mission data receiving, processing, operations management, and communications for the Space Station Freedom, Polar Platforms, and other space missions requiring high data communication rates. The second project constructs a technical laboratory to adequately house the Material Quality Assurance Laboratory and Detector Development Laboratory hazardous operations. The fourth project is an Observational Instruments Laboratory at the Jet Propulsion Laboratory that is crucial to the timely development, assembly, testing, and refurbishment of scientific instruments for planetary, Earth, and astrophysics observational programs, including the EOS program. This project is one of the facilities for which private sector investment is being explored.

Aeronautics and Space Technology

Ten projects comprise the second year of the planned 5-year Aeronautics Facilities Revitalization Program which was described in detail to the Congress during the FY 1989 budget considerations. Work continues on the repair and modernization of the 12-Foot Pressure Wind Tunnel at Ames Research Center, critically necessary for research supporting U.S. competitiveness in civil aviation, and nine projects as originally planned are to be started at Langley, Lewis, and Ames Research Centers.

Two new capability projects are requested. First, a Supersonic/Hypersonic Low Disturbance Tunnel at Langley Research Center to improve the design of supersonic and hypersonic flight vehicles, particularly for drag reduction and fuel economy. This research capability is needed now to remain competitive in high speed aircraft design. The second project constructs an Automation Sciences Research Facility at Ames Research Center to provide basic and applied research in artificial intelligence and automation sciences for space science missions, aerospace vehicles, and a permanent human presence in space.

Minor Facility Projects

Your continued full support of our minor programs request is needed. The Repair, Rehabilitation and Modification, and Minor Construction Projects that comprise the minor programs provide the backbone for NASA's facility support activities and institutional capability. These projects enable us to rectify many of our most pressing and widespread smaller facility problems. With aging facilities, extensive repairs are needed each year to continue to productively use these unique and valuable research, development, and test facilities. Your support has been a key factor in optimizing the use of our laboratories and test facilities to undertake new tasks and exploit new technology. In a like manner, the minor construction projects permit us to build limited, but essential additions, or critically needed small facilities.

Environmental Compliance and Restoration

The new Environmental Compliance and Restoration Program, begun in FY 1988, is proceeding. Detailed studies and assessments are under way, as are remedial construction projects and we are making good progress toward meeting our environmental responsibilities. Although originally envisioned as a 3- or 4-year effort, the constantly increasing environmental requirements and deadlines indicate that this program will require a continuing effort well beyond that timeframe.

A GUARANTEED INVESTMENT

NASA has made and continues to provide a unique and significant contribution to this country and to the world. We must always remember that this contribution is the product of the minds of its people, its human resources. The technology of yesterday, today, and tomorrow will always come from well-trained, highly skilled people with a zeal and thirst for new knowledge and the willingness to explore new frontiers. NASA provides a unique environment for cultivating people who reach out to new ideas. A significant financial investment in NASA personnel now is a guaranteed investment in the future for our country and for the world. Such an investment will payoff manifold in providing new products and technology, as well as the new ideas this nation needs to regain its competitive position in the world marketplace. As succinctly stated by the President during his recent speech before the Congress:

> "We must take action today that will ensure a better tomorrow."

This completes my prepared statement, I would be pleased to address any questions you may have.

APPENDIX 1

NASA PLANNING ACTIVITIES

For purposes of discussing NASA's planning at the Agency level, it is convenient to divide planning into three phases; although in practice, these three phases are not this clearly distinct from each other:

a. Strategic planning guides NASA in general terms and lays out our overall direction. Strategic planning is not a precise tool for determining requirements. Rather, it provides the framework for long-range and near-term planning.

b. Long-range planning sets the objectives for the next 5 to 10 years. It identifies opportunities and broadly defines what the various programs require in terms of infrastructure, Institutional support, and near-term research technology.

c. Near-term planning is focused on the budget and the annual operating plans. The time span covered by this planning is generally the next 1 to 5 years, with the greatest emphasis on the current and upcoming budgets, which are the final "products" of this process.

We have found that strategic planning, if it is to be useful, must be a dynamic process that reflects new factors and emerging trends in the organization's environment. This allows the Agency to accommodate policy or funding decisions, respond to new national needs, or take advantage of new opportunities, such as technological developments.

As the starting point for our strategic planning, we have explicitly embraced a concept that has been at least implicit in the Agency's direction for many years. That is the idea of "frontiers"--physical and intellectual areas that remain unknown. For example, the National Aeronautics and Space Act broadly states that NASA is to conduct aeronautical and space activities that contribute materially to the "expansion of human knowledge of phenomena in the atmosphere and space."

Using such a basic mission statement as a guide, NASA has stated its intent as a vision to expand the frontiers of discovery, understanding, human experience, and technology. Our purpose in doing so is to enrich our nation, ensure a position of leadership, and capture the benefits of space for humankind.

We are applying the concept of expanding the frontiers to our activities on four fronts: unlocking the secrets of the universe; expanding human presence and activity in space; enhancing the quality of life on Earth; and developing and transferring advanced aerospace technologies.

This vision has been adopted to guide NASA into the next century. The next step in our planning cycle is to review and modify specific Agency goals that define this long-term direction in operational terms. Our approach will involve comparing our current programs with the Agency goals to check their fit. We will also develop additional plans and options to ensure that NASA is properly fulfilling the nation's objectives.

We do not expect this new strategic planning cycle to lead to a fundamental change in NASA's course. Instead, we believe our efforts will confirm our basic course, while pointing out the need for adjustments due to new factors that have come into being only recently. However, through the process we will strengthen our ability to demonstrate the interrelationships of our programs and the integration and responsiveness of the infrastructure, institution, and research and technology.

In essence, we are testing the Agency's direction against the nation's requirements and expectations, the challenges of international competition and cooperation, and testing the results against the fundamental capabilities of the Agency.

In reexamining NASA's strategic direction, we are asking whether our programs support our vision of NASA as we expect it to be in the future. At the same time, we are asking whether the NASA Institution is meeting--or is capable of meeting--the current and future requirements of our programs. The manner in which the Institution follows the Agency's overall direction and is able to support its programs is critical to success.

We are meeting this challenge by aggressively pursuing initiatives to strengthen our Institutional capabilities and by integrating our Institutional planning with program planning. An Institutional planning committee, chaired by the Associate Deputy Administrator is chartered to bring together the plans of the organizational components and functions that make up our Institution, as well as develop overarching Institutional objectives.

The results of our long-range planning activities were recently published in detail in our "1989 Long-Range Program Plan," which has been provided to the Committee. As one will not in reviewing this document, an extensive array of program efforts are discussed in some detail concerning the anticipated program activities we are developing over the next ten years.

Additionally, a specific summary of our current strategic direction is outlined in a brochure entitled, "Agenda for Tomorrow," which is based on the planning goals developed and adopted about 2 years ago.

EXPAND THE FRONTIERS

NASA will expand the frontiers of discovery, understanding, human experience, and technology to enrich our nation, ensure a position of leadership, and capture the benefits of space for humankind.

Unlock the Secrets of the Universe

NASA will explore the Solar System and pursue an understanding of the Universe: its origins, evolution, and humankind's place within it.

Expand Human Presence and Activity in Space

NASA will lead the nation's efforts to expand the scope of human activity in space, leading to a permanent and self-sustaining human presence beyond Earth orbit.

Enhance the Quality of Life on Earth

NASA will use the unique perspective and characteristics of space to assist in understanding the Earth and its environment, utilizing the Earth's resources, and developing new capabilities that improve life on Earth.

Develop and Transfer Advanced Aerospace Technologies

NASA will develop and transfer critical aeronautical and space technologies to enhance our transportation infrastructure, promote commercial ventures, advance our economic competitiveness, and contribute to the national defense.

APPENDIX 2

EQUAL OPPORTUNITY

During FY 1988, NASA supported numerous initiatives to help increase the national resource pool of talented minority, female, and disabled scientists and engineers, including its cooperative education and graduate student researchers programs. The agency also expanded its efforts with universities that have significant numbers of minorities who are underrepresented in science and engineering. For example, research grants, faculty fellowships and training were supported by $11.2 million in total awards to 30 Historically Black Colleges and Universities (HBCU's); and this provided support for 24 Faculty Fellows, 465 undergraduate, and 232 graduate students. Efforts at non-HBCU's increased as well.

Women and minorities now hold some key positions in NASA. Some examples are:

- Assistant Administrator for HQ Operations (NMF)
- Deputy Associate Administrator for External Relations (NMF)
- Associate General Counsel for General Law (Blk M)
- Assistant Associate Administrator (Institutions) for Space Science and Applications (NMF)
- Director, Payload Projects Management Office, KSC (NMF)
- Director, Quality Assurance, KSC (Hisp M)
- Director, Management Operations, GSFC (NMF)
- Director, Space and Life Sciences, JSC (NMF)
- Chief, Computer Services Division, LeRC (NMF)
- Chief, Computer Systems and Research Division, ARC (NMF)

As of September 30, 1988, persons with targeted disabilities were 182, or 0.8 percent of NASA's total workforce; and 65, or 0.5 percent of its scientists and engineers. Disabled veterans with 30 percent or more disability were 69, or 0.3 percent of the total workforce and 19, or 0.2 percent of its scientists and engineers.

In summary, NASA has implemented exemplary equal opportunity initiatives; and it plans to continue and to expand these efforts.

NUMBER AND PERCENT OF NASA'S HIRES, WORKFORCE REPRESENTATION, AND NET CHANGES
FOR MINORITIES AND WOMEN IN FY 1988

			S&E'S	P.A'S	TECHNICIANS	WAGE GRADE	CLERICAL	ALL CODES
NMF	HIRES,	NO	99	104	72	2	300	577
		(%)	(15.25)	(37.41)	(17.56)	(5.56)	(68.81)	(31.90)
	REPRESENTATION,	NO	1113	1434	177	25	2046	4795
		(%)	(9.38)	(36.53)	(6.74)	(2.33)	(71.69)	(21.45)
	CHANGE FROM FY 87,	NO	75	105	6	-4	-44	138
BLACK	HIRES,	NO	37	25	32	4	83	181
		(%)	(5.70)	(8.99)	(7.80)	(11.11)	(19.04)	(10.01)
	REPRESENTATION,	NO	481	422	236	138	578	1855
		(%)	(4.05)	(10.75)	(8.99)	(12.85)	(20.25)	(8.30)
	CHANGE FROM FY 87,	NO	31	15	17	-9	-16	38
HISPANIC	HIRES,	NO	24	2	22	3	16	67
		(%)	(3.70)	(0.72)	(5.37)	(8.33)	(3.67)	(3.70)
	REPRESENTATION,	NO	366	87	50	52	93	648
		(%)	(3.08)	(2.22)	(1.90)	(4.84)	(3.26)	(2.90)
	CHANGE FROM FY 87,	NO	11	3	2	0	1	17
AMERICAN INDIAN	HIRES,	NO	1	2	3	0	8	14
		(%)	(0.15)	(0.72)	(0.73)	0.00	(1.83)	(0.77)
	REPRESENTATION,	NO	26	29	15	4	27	101
		(%)	(0.22)	(0.74)	(0.57)	(0.37)	(0.95)	(0.45)
	CHANGE FROM FY 87,	NO	2	3	-1	0	2	6
ASIAN/P.I.	HIRES,	NO	43	4	21	0	13	81
		(%)	(6.63)	(1.44)	(5.12)	0.00	(2.98)	(4.48)
	REPRESENTATION,	NO	437	54	35	29	54	609
		(%)	(3.68)	(1.38)	(1.33)	(2.70)	(1.89)	(2.72)
	CHANGE FROM FY 87,	NO	41	4	-3	-2	-1	39
TOTAL MINORITIES & FEMALES	HIRES,	NO	204	137	150	9	420	920
		(%)	(31.43)	(49.28)	(36.59)	(25.00)	(96.33)	(50.86)
	REPRESENTATION,	NO	2423	2026	513	248	2798	8008
		(%)	(20.41)	(51.60)	(19.54)	(23.09)	(98.04)	(35.83)
	CHANGE FROM FY 87,	NO	160	130	21	-15	-58	238
TOTAL	HIRES,	NO	649	278	410	36	436	1809
		(%)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
	REPRESENTATION,	NO	11872	3926	2626	1074	2854	22352
	CHANGE FROM FY 87,	NO	187	114	6	-87	-62	158

Mr. **Traficant**. Thank you.

Doctor, before we go on, there have been some pictures taken here, and according to the rules of the House, we need unanimous consent to allow for those pictures to be taken, and I so ask for that unanimous consent.

Any objection?

[No response.]

Mr. **Traficant**. Without objection, it will so be allowed.

Number two, I'm going to have to be leaving here. I have a couple questions and I will be leaving, but I want those questions, even though I will not be here, answered for the record. And I will be asking my friend from Kentucky, Congressman Perkins, to chair the committee meeting.

I would ask, if you will, the many Members that are starting to come in, that some of them have flights to catch here later today, and it would be best if you would summarize and submit your written words.

My particular question is two things. Number one, what percent of your GS–15 and SES work force do you think is eligible for retirement? What can be done to provide incentives for them to stay? And what effect would their retirements have on this process?

Dr. **Hinners**. Mr. Chairman, we are now looking at over 20 percent of our SES and GS–15 work force being eligible for retirement. In the next two years, that goes up to 35 to 40 percent. Within five years, we are up to about 60 percent of our SES/GS–15 work force, scientists and engineers eligible.

If too many of those retire, we indeed will find ourselves in a bind for being able to carry out our technical programs You asked what can be done to try to stop some of that. Clearly, an incentive on the pay end is one of those things which would help to maintain that work force.

Historically, people have stayed in NASA ~~five~~ years after retirement eligibility. We are starting to see a decrease in that time scale that people stay on, because at age 55 they still can make another career out in the industry. Now, if we can capture those people for another three years or so, I think we'll have done two things. We'll keep them more than three years because we will probably stop them from making another career out in industry. And I believe at that point they would say, the government has treated us fairly; we'll stay.

Mr. **Traficant**. In closing out for me, I'd like to say to you, you mentioned that your travel allowance needs some help there. I'd like for you, before you leave, to meet with our chief counsel here, Dr. Smith, and some of our staff and give him your opinions on that. We are prepared, and I will offer an amendment to increase that allowance.

Second of all, I was very interested in your testimony relative to 25 of 27 of your people that you tried to get to move to Washington that didn't want to come to Washington. That's a hell of a plight in a great nation like this, in the seat of the greatest government of free people in the history of the world.

I don't know what there might be, but maybe we could put something in the form of an incentive for those that would serve in the

Washington area because of the unique and real serious need that NASA might have in the center of decision making.

I don't know. I don't even know what the legal ramification would be at this point, but maybe an additional pay stipend for those Washington-based needed specialists. If we can't get a pay raise, and if we can't go along that overall omnibus ground, have the rising tide to raise all ships with this pay raise is going to help NASA, how can we address that issue of getting the people you need in Washington, and how would you feel about such an initiative? Or do you have something you think is better? What do you have to recommend here? What's the deal?

Dr. HINNERS. Mr. Chairman, we are ready to work with this committee or any other committee to solve that problem, and this is one of the options I think we need to look at—a special incentive.

You mentioned that 25 of the 27 did not want to come to Washington. That is not correct. The 25, most would have liked to come, but turned it down because of the financial impact. I know that I'm raising a subtlety there, but I wanted to be sure of that.

Those people would come if we could alleviate the financial problem.

Mr. TRAFICANT. Very good. See, I don't know what we would open up with many of the other divisions of the federal government in our budget with those people that would be working in and around the Washington area. But I think if we can present it in the specific area of extreme importance, the delicate issues and sensitive issues, and the need that you have, that maybe something can be done there. I don't know. We sure would be glad to try and help with that.

So I appreciate it. I'm going to turn the gavel over to Representative Perkins here from Kentucky. I thank you very much, and I hope that most of these problems can be resolved.

Dr. HINNERS. Thank you.

Mr. TRAFICANT. Now as I turn it over here, we have Representative Skaggs from Colorado. Do you have any questions of Dr. Hinners?

Mr. SKAGGS. Thank you, Mr. Chairman.

I noticed in some of the analysis that our committee staff did, a fairly dramatic erosion in the ratio of NASA personnel to contractor personnel over the last 10 years or so. Is there anything inherently evil about that? Is there a magic number there that we should be cued by? What is the significance of those ratios?

Dr. HINNERS. Mr. Skaggs, your observation is correct that the ratio of the contractor to NASA employee has gone up.

No, there is nothing inherently evil about it. Some of that is warranted and it is probably good. Say, for example, I believe there is no reason why you need a civil servant cutting the grass. A contractor operation can indeed do that quite well. In fact, there's sometimes benefit to it. You can fire that grass cutter if you don't like him.

On the other side, we have gone too far. What we are doing now is, for example, having some of our in-house engineering talent contractor-supported. In other words, an electrical engineer within a NASA laboratory working on our program is a contractor. We believe that we should have the basic discipline capability in our engineering work force to do the evaluation, to do the detailed planning, to be accountable as a government employee.

There are places where we have contractor engineers doing our monitoring job in other contractors' plants. The contractors don't like that either. That's the kind of thing we should get away from. We don't have a lot of those instances yet, but we do have some and we should get out of that kind of contract support.

Mr. **Skaggs**. So you're hiring Lockheed to oversee McDonnell-Douglas.

Dr. **Hinners**. It's of that nature. Yes.

Mr. **Skaggs**. I assume that the case can also be made that if we were to take the action we should on the overall civil service pay structure or take measures to give you the flexibility you may need beyond that, that by spending more in that line we would save more than we spent in the contractor line.

Have you done any real dollar and cents analysis of what we could save by doing more in house that now has to be contracted out because you simply can't pay enough to attract the talent you need?

Dr. **Hinners**. We have done some looking at that and, believe me, it does get complex. I think there are some instances where it's probably a wash in terms of the dollars spent. In other cases, I believe it is a higher cost to go to a contractor.

There is an insidious side of this, though. It's as follows. If you have a contractor working side by side with one of your civil servants, or close to it, and that contractor is making $10,000, $20,000, or $30,000 more, you have disincentivized the civil servant who is doing essentially the same kind of work, side by side.

But also we are creating our own competition. As we increase our on-site support contractors, we are creating the opportunity for our people to just change badges, if you will, and do essentially the same work. So it feeds on itself. I think we need to be sure that we don't encourage that type of feeding.

I did want to comment on this cost business. Much of the constraint on personnel indeed is generated in the administration and is not a total cost issue. With fewer civil servants, indeed government looks smaller. But we have to get the work done, and so we'll go hire a contractor to do it. So the total work force is not any different, but the government piece of it certainly looks smaller. But the down side of that is that we have given away some of our responsibility, accountability, in doing that.

Mr. **Skaggs**. This May 16 date looms out there, driven as I understand it by changes in the rules of employability in the private sector. As a practical matter, is there really anything we can do in the next two months, six weeks, to make any difference about that, or is the die cast there?

Dr. **Hinners**. There are things. Our chief counsel who is here can address this for clarification, because it's largely a problem of ambiguity. At least it may be, because it's ambiguous. But Mr. Frankle, our chief counsel, could comment on that.

Mr. **Skaggs**. Please.

Mr. **Frankle**. Mr. Skaggs, the problem that was being felt generally about this bill—it was part of the procurement integrity section, Section 6 of the Office of Federal Procurement Policy Reauthorization Act—was that there were some provisions that were added which were very unclear.

Many people who, as Dr. Hinners was saying, are eligible now to retire, were thinking that they were going to have to retire now to avoid the uncertain application of restrictions. Over the last week or so, we have worked very closely with the Office of Federal Procurement Policy, the Office of Government Ethics, Department of Defense, and some other organizations, and I hope today there is going to be a memo sent out to the heads of all of the executive departments and agencies concerned with consensus interpretations of the terms of that bill.

It will be done in a question and answer form, and those questions and answers I think will alleviate most of the concerns. There are some new restrictions on the people who are leaving which, if that causes them to leave, that will happen. But the added increment that might be caused by uncertainty, I think we have alleviated a lot. So many of the concerns we have had about the bill will probably go away with the issuance of this guidance.

But I don't want to understate the fact that changes, especially ones that are not well explained and defined in post-employment restrictions and other conditions of employment, have dramatic impacts in the retention rates of people who are eligible to retire.

Mr. SKAGGS. Suggesting that Congress might be able to clarify its intent in this area is a hazardous notion, I realize. But perhaps if you get to the point where even the best lawyers can't figure it out, some resolution that might be clarifying could be considered on an expedited basis.

I think there are an awful lot of us that are aware that we've got a real bear facing us on this and want to do what we can to alleviate the situation.

Could I just have a show of hands of the gentlemen at the table, how many of you will be around after May 16?

[A show of six hands.]

Mr. SKAGGS. Okay. Thank you, Mr. Chairman.

Mr. PERKINS [presiding]. The Chair would encourage the Directors of the various Centers who have hands-on experience on a day-to-day basis on some of these affairs to comment on some of these personnel questions as well.

Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman.

Is money the only problem relative to longevity, keeping top-notch personnel? Is it solely a question of money or are there other concerns or problems that we've not addressed?

Dr. HINNERS. I would like to start with that, but I would certainly encourage the accompanying Center Directors to comment on this.

I think there are other concerns also, Mr. Packard. It is becoming—and it's been happening for a long time—increasingly to, as we say, get the job done because there are increasing regulations, reviews, that get in the way, say, of getting the hardware fixed, getting it ready, getting it flying.

The procurement process is very cumbersome. If you look back 20 years ago, it was just a lot easier and quicker and probably more economical.

Mr. **Packard**. So there is a frustration——

Dr. **Hinners**. There's a frustration; yes.

Mr. **Packard** [continuing]. That has gotten to be a much higher level now than what some of our long-term employees remember it being.

Does that frustration and the low pay, does that reflect a morale attitude change?

Dr. **Hinners**. I think it would be appropriate for our Center Directors to comment on this. Dr. Townsend.

Dr. **Townsend**. The biggest issue clearly is the pay issue. We can attract, at least at Goddard, some very good youngsters. They are top of their class people in engineering, professional administration. We can then keep them because we can give them more responsibility at a given age, up to a certain point, than they would ever get in industry. And they can become involved in project management 10 years, probably, sooner than they would out in industry.

But then the problem of money really hits, because industrial pay in, say, the GS-15 level, base pay is at least 20 to 30 percent higher, to say nothing of bonuses. And that's about the same time that, as a youngster, you begin to think about educating the kids and oh, my gosh, I'm going to retire some day, and I've been spending all my money; what's going to happen?

Mr. **Packard**. So we're seeing the exit mostly after they've been——

Dr. **Townsend**. I'm losing my very best ones just in their early fifties, because it's then or never. Industry, if you're targeted—and I was in industry for 10 years—for greater things in industry, they want to get at least 10 years out of you, and two or three of those years they're going to want to train you, and then they're going to want some useful output. So sometime in the early fifties is the end.

Mr. **Packard**. So we're losing them in mid-career.

Dr. **Townsend**. Yes, that's right.

Mr. **Packard**. We get them started and there's the lure and the glamor of coming to work for NASA. They come in out of school, or after a short time in the private sector, and then we train them and we groom them and then we lose them. And those in the good old days stayed with us and it seems that now that is the predominant group. Fifty percent, as I recall your figure, are over 45.

Is there some way we can change the structure of pay and pay incentive, et cetera? In other words, are there different ideas relative to, for instance, including the pay in project bidding, even inhouse pay? We do it with contracting. If you have a project such as a portion of the Space Station, and you do it by contracting out, the contracting out costs are all included in the project bid.

What about including the bids on a project—if we looked at different ways of structuring it so that we correct the pay deficiency by structure rather than by constantly a handout for more pay.

Dr. **Townsend**. While he thinks that one over, let me make one other point, though. I think that there is a bright spot. For the last probably decade, there has been a factor that has hurt a lot of people, and that has been what I call the trashing of the federal employees. Several administrations have run against them.

Mr. PACKARD. I think we understand that.

Dr. TOWNSEND. Yes, I think you understand that one. Now, that one has changed. The perception is that—well, it's more than a perception. I am part of this Center for Excellence in Government operation, and we met with all of the presidential candidates. And, to a one, they agreed not to run against the bureaucracy this time, and they didn't. And I think it made a big impression on my employees. You know it's not all bad. That was good.

Now, that other question you're asking, why don't we program budget, which is what we do in industry—you can answer that one.

Dr. HINNERS. I like the idea. It would take quite something to implement it within the current civil service structure, but it is not inconsistent with another option we are looking at, although not extremely seriously at this point.

That is, if the problem appears to be that we are unable to resolve it with the band-aid approach, small changes to the current structure, the drastic alternative or a drastic alternative is for the NASA centers or laboratories to become government-owned, contractor-operated, similar to, say, the Department of Energy laboratories—Sandia, Los Alamos, Livermore—in which case, essentially you do have everybody on an industrial funding basis.

Mr. PACKARD. We're caught in a dilemma. At least I am constantly approached by federal employee groups and representative groups that want less and less contracting out and yet, at the same time, want more and more, better and better benefits and pay. That's a dilemma because it's almost a catch-22 for us who actually have to do the funding.

The President has proposed a pay package within the last day or two. Will that include some of the higher NASA people, or will it get down into the areas of problems?

Dr. HINNERS. Mr. Packard, I have not seen a specific proposal yet. The President has received, of course, the Volker Commission Report and, through his press secretary, has said he would support a 25 percent pay raise for the judiciary, maybe with selected——

Mr. PACKARD. We're not aware at this time whether that will dip down and correct some of this?

Dr. HINNERS [continuing]. No, I have not actually seen a specific proposal on that.

Mr. PACKARD. There's an implication that the experts are now getting ready to retire, that being those that have been around a long time. I wonder if that implication would be an indication that therein lies the expertise in those that have been around a long time. Are we attracting fresh and bright young men and women that will become experts in their own right within a short period of time, simply because of their educational background or their own personal brightness? Or is experience and longevity the key to our success in NASA and in our space program?

Dr. HINNERS. I think it would be good to have General McCartney answer part of that, and then Mr. Peterson from the researcher end of it.

General MCCARTNEY. Sir, there is no question in my mind that a significant key to a successful program, longevity program, is understanding what lessons were learned, understanding the implications of those lessons, and applying them. If there is any business around that's not very forgiving, certainly space endeavors lend themselves to the type of efforts that—it's nonretrievable hardware in many cases, and in other cases that hardware which you anticipated retrieving could become nonretrievable.

Bottom line is I think the health of the space programs is directly dependent upon applying lessons learned. And that implies to me that you need to have people that are perceptive, that are experienced and have longevity.

Mr. Packard. Spoken by a true veteran. And yet I'm not being critical in that comment. I understand.

General McCartney. Yes, sir.

So I would think that the objective would be to, as you say, attract people who are motivated—and continue to motivate those people—and bright. We have been hiring perhaps more at Kennedy because we have been building up for the return to flight, and some of the other centers have been very fortunate on it.

I can say unequivocally that from the engineering standpoint, we've tried to get younger folks just out of college and the quality of those people is simply outstanding. So yes, sir, I think that the quality of some of the new hires is such that it will serve our nation well for a long time.

Now, there are other fields we have been hiring in which we were not particularly interested in getting young people. We wanted some more experienced people, for example, in the areas of quality inspectors. We would like to certainly get some young inspectors, but we also want an experienced work force in that area.

But let me just address what I'll call the engineering and scientific part of it. I think the challenge then comes in trying to motivate and keep those people for a length of time so that we can retain that experience. It then becomes a matter of yes, you can entice them only so long by the thrill and excitement of what they do. Beyond that, they become the very down-to-earth real needs of supporting families, having families, supporting them, education, and these sorts of things.

And that is why I think we've seen the middle management erode. The more we contract out that effort, those exciting jobs, the less incentive I see for these people to stay in and become middle managers. I look at the work force we have down at Kennedy now, and I do not have the level of middle management, retaining that middle management that we really need.

Mr. Packard. You're caught in a catch-22 also. You don't have the people after a time; therefore it almost necessitates contracting out.

General McCartney. Yes, sir.

So I think getting back to something that Dr. Hinners mentioned, of major concern here is to maintain within NASA a core of capable experienced people. And in my judgment, there is absolutely no substitute for the lessons learned in experience.

And in order to keep an experience base which NASA has had, certainly in its last several years, it just necessitates an attractive way of maintaining "fresh outs."

Mr. Packard. I know, Mr. Chairman, I have used more than my five-minute limit. Let me ask one very short question. Hopefully it can be answered shortly.

Are we seeing a greater number of foreign entry bright minds coming because we can't attract those of our own?

Dr. HINNERS. No. In part, because we can't hire them.

Mr. PACKARD. I see.

Mr. PETERSON. Right.

I might just briefly respond. Langley is a Research Center, and our situation is a little less dependent on experience. Bright young people have some of the best research ideas. We do need leadership which comes from experienced people. We do have some problem with this shortage in the middle management area, but not as much I think at the Research Centers.

I wanted to go back, Mr. Packard, if I could just quickly, to is there something else besides money—and I agree very much with what Dr. Townsend said. I would add one other thing, and that's the strength and the leadership of the NASA space program and aerospace program.

If we have a world leadership program, that to me is the next most important thing next to the money. If we take a big cut and terminate the Space Station, that's just about as bad as not having adequate pay for the people.

Mr. PERKINS. Mr. Nagle.

Mr. NAGLE. I have no questions. I just want to assure the panel I hear your concerns on pay, post-employment restriction. And I, along with other members of this committee and some other Members of Congress, are working desperately and quickly to try to alleviate both problems to the extent that we can.

I think your points are exceptionally well-taken, and I concur and pledge my support to try to help you resolve it.

That's historical. I normally ask a lot of bad questions. [Laughter.]

I wouldn't say you'd be shocked, but certainly you should be honored. And a little side bar agreement you and I can have, don't tell Dr. Fletcher I did this.

Mr. PERKINS. Gentlemen, there have been a number of things written and discussed about the new types of machine technology, the "smart" computers that are being entered in and being programmed by NASA to try to take up some of the slack when some of the people are going to be retiring in the next two years.

What is the effectiveness of this program? I would like to hear some comments on it.

Dr. HINNERS. Mr. Perkins, just to clarify that, maybe you're referring to expert systems?

Mr. PERKINS. Yes.

Dr. HINNERS. Let's see. Dr. Townsend, I believe you have some experience with expert systems at Goddard in some of your operations.

Dr. TOWNSEND. Yes. There is no question but that there is a lot to be gained, particularly in the operational environment. Automated watching and control of satellites is an area where you have a monitoring position of some sort. One person is not really one person; it's about five or six people because you're operating 24 hours a day, seven days a week. So each position in front of that console costs you five to six warm bodies.

We are making a lot of headway in expert systems that watch out, and in the case of an anomaly, the simplest thing they do is flash an alarm. Some of the more advanced systems are actually taking the corrective action automatically, sending the upload command. And there is much to be gained there.

The other thing we're doing, and I don't mean this facetiously, but I think it's true—we couldn't answer all the questions, investigations, and special interest programs if it weren't for our computational base and handling large data bases, the procurement questions.

In many areas of special interest, we are asked for a report frequently. He mentioned this in his testimony. And without the base of computers that can handle large data bases, we would have an administrative horror. That is, we would have a lot more people just using the old railroad paper and pencil and pens.

I'm on the older side myself, but I have fun with a computer. Now, I keep mine at home because I consider it play if I do it at work. But, seriously, there is a big advantage here. But don't kid yourself in one sense. It's not artificial intelligence. I hate that word. It's expert systems. All that intelligence comes from people who build it into those programs.

Now, there are some programs that are beginning to do things that are somewhat similar to intelligence of sorts, but I think that word is too much, there is too much hype there. But expert systems, thinking over all the possibilities that can happen to you and what the consequences are, and what you should do, there is a lot to be gained there.

General McCARTNEY. Mr. Perkins, at Kennedy we have made a special effort to try to identify those routine processing jobs that are very manpower-intensive and see if we can get the automation type of systems automated or some innovative high technology that would reduce the level of involvement by the person just from an efficiency standpoint.

And I am very pleased with some of the things we've done, particularly in the tile world. We have been able to devise measuring devices that not only allow us to do the job more rapidly, but allow us to do it more accurately.

So our job at Kennedy is one more, as you know, of processing and production type of work. But yes, sir, we are working that area very hard and I am pleased we have made the progress that we have in it.

Mr. PERKINS. Gentlemen, do you think that this is going to play a significant role, increasingly so I guess in the future, with the additional requirements that seem to be imminent? Is this going to be something that's going to be able to take up the slack, or is this just a tool that we can hope to use as best we can for efficiency?

Dr. HINNERS. No. I think it's really going to help, but it's not the total answer to our experience.

Dr. Townsend and then Dr. Robins.

Dr. TOWNSEND. I would say this; that what it's helping us do is to keep up with the complexity of the new tasks. The satellites are much more complex. The things we do with them operationally are much more complex. Our research experiments are much, much more complex.

It's in that area that these things will help, but I don't think that they're going to make a big difference in the fact that you need a very highly skilled professional work force, and I mean both scientists and engineers as well as administrative people. There is just absolutely no substitute for good judgment, which in my book is the number one management quality.

Dr. **Hinners**. Mr. Perkins, I think Dr. Robins might add a few words here on our Program Project Management Initiative along these lines.

Dr. **Robins**. Yes. During the past two years, we have started a new initiative called the Program Project Management Initiative. This was something we started after the Challenger accident. One of the things we did once we got past the immediate cause of the accident was to start to look at maybe some of the things in the institution that might have contributed to that.

One of the things that we came up with that was universally popular and adopted by just about everyone as something we ought to do is start formal training and development in program and project management. Despite the fact that it, along with the research that's done at the Research Centers, this is the heart of what we do in NASA—we're either doing research in engineering or we're doing program and project management. And while we have institutionalized more than 30 years ago a technical training and development program for engineers just coming in through graduate studies, things like that, we did not have any formal program whatsoever in program and project management.

Well, within the past two years now, we have built up. We must have something like about 15 courses that we are piloting and running and we're still expanding that list. We think this is going to be a big factor in helping us deal with this middle management gap that they've been talking to you about; and, further, increasing the productivity along the lines of what you were talking about relative to expert systems—but by transferring the knowledge in a more structured and orderly and rapid fashion than just OJT, which is what we relied on in the past.

One other thing, too. You have to remember that most of us—in talking about the importance of experience—it gets brought up every now and then that Apollo was done by those of us sitting here at the table, and we were very young at the time. It was also true there was no knowledge base. A lot of the people that are with NASA today that we're talking about and being concerned about going out the door are the people who invented the space field.

And so there is a lot as far as lessons learned that has to be transferred, and this formal program I think is going to be very helpful in doing that.

Mr. **Perkins**. Are there any additional questions? Mr. Skaggs?

Mr. **Skaggs**. Thank you, Mr. Chairman.

Just one follow-up, for me anyway. I see seven key managers from the organization in front of us and start to do a little mental arithmetic about what that's costing us. In having you away from your jobs, I hope you had some other reason for coming to Washington to make this hour or so worthwhile.

In particular, General McCartney and Mr. Anderson, I would hate for you to go home saying to yourselves, I wish they'd asked me the following question and, boy, would I have knocked that out of the park. [Laughter.]

If there are any of those wishes lurking in your minds, I'd appreciate having an opportunity to hear from you all, since you have been kind enough to be here this afternoon.

Mr. **Nagle**. Or you can quit while you're ahead. [Laughter.]

Mr. **Skaggs**. Very well. Thank you, Mr. Chairman.

Mr. **Perkins**. We are going to submit some additional written questions to you that we would like for you to answer for the record. But at this juncture of the afternoon, with everyone seemingly well on their way to being ahead, we are going to adjourn this meeting and thank the witnesses very much for their testimony this afternoon.

[Whereupon, at 2:45 p.m., the hearing was adjourned.]

1990 NASA AUTHORIZATION

TUESDAY, APRIL 11, 1989

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met at 1:30 p.m., pursuant to notice, in room B352, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Present: Representatives Nelson, Volkmer, Mineta, Packard, Perkins, Johnston, Lamar Smith of Texas, Rohrabacher, Morella and Walker.

Mr. **Nelson**. Good afternoon. We are going to have an exciting hearing today. Excuse the disruption in the Committee room, but this is what happens when a lot of hearings get scheduled at the same time. You are going to see me occasionally throughout the course of this because at this moment there is a pending Nelson amendment to the Savings and Loan Bailout Bill in the Banking Committee.

I welcome you today. We are reviewing the fiscal year 1990 NASA request, and we particularly want to zero in on the Office of Commercial Programs.

We are going to be having an interesting time this week for this Thursday in the morning at 9:30 we have invited from all over the country and Canada witnesses who will display a variety of technological spin-offs of America's space program. A lot of these spin-offs have been reapplied in medicine, public safety, education, energy, energy conservation and so forth.

Now this will be in the big Committee room and we will have these displays all set up, and at one point in the hearing we are going to have like a show and tell. They are going to actually demonstrate the particular technological application. Now that's just a part of the nation's space program that we need to get the word spread. A lot of people do not understand those spin-offs. So we are going to try to do that on Thursday.

Next Tuesday, April the 18th, we will have the Department of Transportation's Office of Commercial Space Transportation, their presentation of their budget and related issues.

Now today we will hear on the substance of the commercial space budgets and the policy issues. We have had a lot of discussion of commercial space. We have had misnomers come in front of this Committee called commercial space initiatives that are not that in the true sense of the word. They are budgetary implementations.

They are budgetary mechanisms for trying to fund a $13.3 billion budget, and actually get about $14 billion in it.

So let's talk about commercialization today in the true sense of the word. How can we explore the commercial potential of space? What we want to understand is what kind of government/industry partnership is going to be required to ensure that industry has the opportunity and the confidence to invest in exploring space-based operations. How can we be certain that industry is poised to capitalize on permanent manned operations in space, and to do that in the very next few short years? How can the United States remain preeminent in space and meet the competitive challenge that has been presented by increasingly sophisticated industrial space powers abroad?

After we lost Challenger we embarked on a course that would ensure that future space transportation requirements would be met by a mixed fleet of space vehicles. We needed a commercial launch industry that would flower from those ELVs for the government.

You have often heard me give credit to the then Secretary of the Air Force, Pete Aldrich, for including within his RFP for those government vehicles that would complement and be an extension of the Space Shuttle in our having assured access to space for our nation's security. In that RFP he offered that one of the considerations was going to be the development of commercial ELVs.

Well, our experience throughout this last two years concerning how to encourage this kind of development of a commercial space launching industry showed us that commercial space industries simply won't be developed because we want them to or to call them so. The government is going to have to be involved.

The commercial use of space will not develop unless the government provides the opportunity, and we must learn how to develop that new model for government and industry cooperation that will allow new products, processes and services to develop.

In the case of the commercial space launch industry we forged that new partnership in the legislation that was enacted into law last November, and it basically had the government sharing the risk on the liability question, on the damage to government property. It had the government not being able in an arbitrary fashion to bump space launches, but it had to be "imperative national need," and that was not decided by some low-level Commander, but decided by a joint panel of the Secretary of the Defense, the Office of the Secretary of Transportation as well the Administrator of NASA.

Now to address the needs of the commercial users and developers of space products and services we want to take from that experience that we went through, the drill we went through on the commercial launch initiatives and the drill we went through on the ISF or the CDSF or whatever you want to call it, and now we want to begin afresh. We want to listen, we want to debate and we want to discuss the requirements of industry so that government can be a willing and cooperative partner.

Now we are going to receive your advice today. We want the advice of the guy who is leading the charge for NASA and we want the advice of you all who are the prime entrepreneurs from industry.

Ed Donley Chairs NASA's Advisory Committee on Commercial Space, a new committee of the NASA Advisory Council.

Charlie Schmidt served as the Chairman I guess of what was the Commercial Space Advisory Committee that was a committee formed originally by the Secretary of Commerce Verity.

So we welcome you.

We have the two Directors of NASA Centers for Commercial Development of Space, and we have Jim Rose, of course, as I referred to here as the Assistant Administrator for Commercial programs.

Now we will enter in the record Mr. Sensenbrenner's statement.

Mr. NELSON. Let me in a personal way say that we are delighted to have Dr. Bugg here. I had the privilege of working quite lengthily with Dr. Bugg in which is called protein crystal growth. This gentleman has national acclaim, and this gentleman has taken what is a Nobel winning process here on earth and said if we can find out about the secrets locked in the architecture of proteins by growing crystals on earth, can we do that so much better by taking those proteins in liquid form to the zero gravity of orbit and grow the crystals there.

What he has found now over having flown this experiment on several Space Shuttles is he is starting to get the data that indeed says yes. Crystals grow larger in space, crystals grow, to use the layman's terms, more pure. So that then when we bring those crystals back to earth and analyze them either with X-ray defraction or with an electron microscope we have a better chance of unlocking the architectural secrets or the molecular structure.

And when we do that, then we have just made the quantum leap because we can then manipulate the protein to do what we want it to do. In something such as cancer research, which was the prime purpose of the experiment, but of which recent flights have been made with proteins having a link to the protein governing the replication of the AIDS virus, the potential there is extraordinary.

So we are going to have some exciting testimony.

Without objection, we will have unanimous consent for photographers.

I'm going to ask Mr. Volkmer if he would take the Chair so that I can go back and offer my amendment in the Banking Committee, and I will be popping in and out throughout the course of this hearing.

So we welcome you all very, very much and are looking forward to this.

Mr. VOLKMER. Thank you very much, Mr. Chairman.

The Chair will recognize the gentleman from California.

Mr. PACKARD. Thank you very much. I don't have an opening statement prepared, but I did want to certainly express my appreciation for this hearing where we will discuss what I consider one of the very important issues before this Committee, and that is the commercialization of space.

We made some small breakthrough I think in legislation last year, but that was really only the beginning. I think there is much, much more to be done. I have legislation pending that we are still putting some final touches on, and I'm sure there will be others that are looking for ways to unlock the private sector in terms of our space program. We've got to find ways to develop a better cooperative effort and still unlock the private sector to do things that they can do best.

There is no way that this government is going to be able to fund all that we want to do and all that we ought to do in space. There are simply not going to be the dollars to do that, but if we can joint venture with the private sector and allow them to do things much more, I think that we will be able to go a lot further and a lot faster in our space programs.

So I'm looking forward to your testimony.

Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you. I, too, look forward to your testimony. That's why I'm not going to say anything.

We'll begin with my good friend, Jim Rose.

STATEMENT OF JAMES T. ROSE, ASSISTANT ADMINISTRATOR FOR COMMERCIAL PROGRAMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. ROSE. Thank you, Mr. Chairman, and thank you, Mr. Packard.

It is a pleasure to be here because I do think in the Office of Commercial Programs we have three of the more exciting areas I think. It's totally wrapped up in the U.S. international competitiveness issues of the day. The technology utilization activity that we carry out, the commercial utilization activities and the small business innovation research programs are all part of my office, and therefore I think we are doing some very exiting things for the Nation.

Because we are going to have the special hearing on the 13th where we are going to really demonstrate many of the spin-offs that have originated from space technologies that have been developed over the past, I am going to really restrict my comments today to just the budget for the technology utilization program and briefly discuss the SBIR program so that we can spend the majority of this particular hearing on the commercial space development program.

If that is suitable, then I will submit for the record the written testimony and simply give you an oral summary of what we are talking about.

Mr. VOLKMER. All written statements will be made part of the record at the point in which you testify. So we appreciate your summarization.

Mr. ROSE. Relative to the technology utilization program, the 1990 request is for $22.7 million. This money will accomplish the following: We will continue to broaden our applications projects, which are those projects that we work with industry looking for where technologies can be applied to gaps in the industrial community, and these are where a lot of our spinoffs come from.

We will also be using these monies to improve our transfer of technology through an automation system called TONS that we are putting in at all of our industrial application centers in the various States that we work with.

We will also be adding to our staffs at the centers to improve new technology identification. If you can't identify the technologies appropriately, you don't have technologies to transfer. So it's vitally important that we continue to work to make sure that all technologies are adequately identified and reported.

We will also be expanding and increasing the scope and breadth of our 10 industrial application centers that we support directly, and these centers in turn have affiliates that are now in about 42 or 45 of the States of the Union. So we've just about got a network that covers all States.

As far as the small business innovation research program, as you know, our R&D budgets are taxed at one and a quarter percent that goes into small business. The program has been in existence for about five years. We had an audit this year by the GAO. I'm proud to say that I think the program has been quite successful within NASA.

All of our center directors who were asked to review in detail the accomplishments of this program and how well this technology is being used or received within their respective centers have all unanimously commented that the technologies developed by the small business innovation research programs are equal to or superior to other forms of technologies that they have sponsored in the past. So we believe the program is working.

To give you an idea, in 1989 it was a $53.3 million budget for small business innovation research. In 1990 it's going to be $71.9 million. Last year we had Phase I proposals or grants of $206 million, and Phase II, which is the 500,000 per grant are moving into a more applications oriented technology of 100. This year we are anticipating that we will grant about 225 Phase I awards and 112 Phase II.

To give you an idea of the scope, in 1988 we received 2,379 proposals from small businesses. That is a 30 percent increase over the 1987 number of 1,800-and-some. So we believe the small business is a very important part of the whole idea of competitiveness in this country, and we are looking at how to bridge small business into our centers for the commercial development of space so that they have longevity well beyond the Phase II's that get them started. So we believe that we are making progress in that and our centers are going to be an active participant in the SBIR program.

Let me now turn to the commercial development of space program. Obviously you folks set us up. You gave us a job to do, to seek and encourage to the maximum extent possible the fullest commercial use of space by the private sector.

I think there is another goal that I want to set, and that is to personally see to the best of my ability that the United States' industry reaps their full share of these rewards as opposed to our international competitors.

We think we have done a lot of things and got a lot of things started that are going to be essential if we are going to have this new beginning that Congressman Nelson spoke of earlier. I want to highlight just a few of them for you, and then we are going to talk a little bit about several of them in detail because I think that sets the stage for my colleagues here from the Centers for the Commercial Development of Space.

One, we have been successful in acquiring specific skills in my organization. Where we really needed people, we have been able to get good qualified people to do specific jobs that are now beginning to emerge.

We have established a Standing Commercial Advisory Committee made up of senior level CEO and university heads, and Ed Donley, who will testify today, is the chairman of that committee.

We are nearing completion on a long-range strategic plan with an organized insight from industry. Industry has played a major role in helping us to define goals that we should be striving for up to the year 2025.

We have created cooperative operating management system with the Centers for the Commercial Development of Space, and I believe that in getting our act together and organized, that's why we are seeing a tremendous output from these Centers at the present moment, and some of the results we are going to tell you about today are very exciting.

We have developed a flight plan to maximize transportation opportunities for the CCDS payloads and our joint endeavor partners. In 1989 we have 22 flight tests scheduled that will involve some 40 companies outside that are working with us. So I think the record is going to show that we are beginning to get industry heavily involved in getting into space and trying some of the technologies that they are developing.

We have successfully initiated complementary programs between product development groups, these product areas we are talking about and with transportation and infrastructure groups. We think that this is going to be a major stepping stone to getting commercial space off and running. It's the integration of some of these aspects of product developments with infrastructure and with transportation.

We have signed six new NASA industrial agreements that include the first agreement for a commercial suborbital use of external tanks. Also, we have signed an SSDA, space systems development agreement to launch the SPACEHAB, which is a commercially developed facility for six flights scheduled to start in 1991.

We are also now in the second phase of evaluations of three additional external tank proposals which were submitted in response to a CBD announcement that we made some months back.

And last, but not least, we are carrying on discussions with eight new companies who are seeking joint endeavor agreements with NASA in order to go and develop technologies of interest to them.

[Slide.]

I think it's important to note that you've got to look at space commercialization in categories because it's through categories that we determine what are the real requirements, what is government's role and what is industry's role, because the maturity and the nature of these areas of commercial space do differ, and therefore we believe that we've got to understand what the differences are in defining what it is we need to do.

So we have chosen to break them down into what I call information systems, transportation, infrastructure and new products and services. I don't need to read you what they are, but the information systems is communications, remote sensing and navigation. Transportation and infrastructure are those elements that involve anything from swimming pools all the way up to SPACEHABs and other carriers and other forms of support to the Space Station and other aspects of our space program. New products and services of course are developing new markets.

Now since commercialization of space is going to be done by the private sector, and I think we all agree with that, we felt it important to get the private sector involved in our planning and in our oversight. So to that end we have initiated two strategies this past year.

One was to establish a Standing Advisory Committee, which we have done, and what we have chartered that group to do is to help us determine what are the proper roles of industry and government from their perspective in information systems, transportation, infrastructure and new products and services.

There are 18 CEO and university heads that make up this committee, and in fact we are meeting this evening and then tomorrow. So we have an ongoing activity to develop a report and recommendations from this committee that will be available sometime in the late May or early June time frame.

Another initiative was creating and helping us to create a strategic plan for the commercialization of space. As I said before, how do we know what we should be doing if we don't know where we want to go. So we asked the AIAA to bring together a group of industrialists primarily, and they did so.

They brought 90 people together to help us strategize goals and objectives that we could strive for between now and the year 2025 in seven areas such as transportation, remote sensing, materials processing, life sciences, infrastructure, to name a few, and navigation. Each one of those have now been developed, and this report is in the hands of our advisory committee and becomes an integral part of our report in the May time frame.

So we have engaged industry, we do have them involved and with our standing committee now I think we are in a position to draw heavily inputs from the industrial side as to what we should be doing.

Now for true commercialization to take place, and I think we all understand this, we must develop private markets, private products and products by the private sector. If we look at the areas of breakdown, the information systems and the new products and services are the areas that will develop new markets and new products. Transportation and infrastructure support their development. New products will ultimately drive the requirements for transportation and infrastructure and it makes the whole system begin to go around.

So we believe we must concentrate our support on those efforts that are needed to stimulate the private sector to get involved in developing products and services and those infrastructural items which directly support those market developments and can be transitioned from government use to private use downstream if it all makes sense. That is the approach that I'm looking at and we are looking at in the Office of Commercial Programs.

Now for those programs that require products, especially life sciences and materials processing, and I think you'll hear on that today from my two colleagues here, it might be 5 to 10 years before an actual application or a cash flow begins from an industry participant. Therefore, we must find ways to provide the incentives to help these industries develop.

We have two such methods. The first method is what we call the joint endeavor, and I think every one is familiar with the joint endeavor. NASA has had it for some years, but it is a cooperative effort between an industry who has reached the point that he is willing to put up his own research monies for a long-haul development program and we will provide incentives for him to go do that by providing access to our facilities on the ground and flights aboard the Shuttle while he is in the process of developing those technologies leading to an application.

We currently have five active joint endeavors in process. The most prominent one of these is the 3M Corporation, which I think you all are aware has been involved and will be involved for a 10-year program.

We are looking at establishing eight new ones. One of those eight is a company called Corabi International. Corabi is interested in commercially providing a telerobotic work station that transmits a high resolution video image of a patient or a sample specimen to a ground work station anywhere in the world. This system has the potential for medical specialists to remotely view and analyze biological and other materials located aboard the Space Station Freedom.

So they want to provide a piece of infrastructure to the Space Station program and are willing to invest their own monies in developing the technology in conjunction with NASA's needs in order to make that happen. So there is an opportunity for us to get a high technology infrastructural element into our program.

Now for those firms not in a position to commit to long-term investment NASA has established the Centers for the Commercial Development of Space. The CCDS's are a consortia of university, industry and government involved in early research and testing stages of potentially viable products or services.

We believe these are very unique centers because they work directly with industry, industry drives the research that they are carrying out, but it's done in a focused way to take full advantage of what academia has to offer, and the government, we support that activity. But here is a way to get industry involved who haven't really made the commitment yet to a long-term development program, but are interested in what space might have to offer. We think it's going to work. We have created 16 of these centers.

[Slide.]

I'm not going to name them off, but you've got seven areas of technology that are being worked on. You've got two in automation and robotics, three in life sciences, five in materials processing, two in remote sensing, two in space power, one in space propulsion and one in space structures and materials.

Now we believe this is going to be the way that we are going to get a wholesale involvement of American companies in looking at space as something to perform applications or from space to perform applications on the ground. Let me tell you why I think they are working.

[Slide.]

These 16 centers now have 48 universities directly involved with research of one nature or another that is being carried on in these centers. We have 48 universities working.

[Slide.]

Probably more important, we have 128 companies that are involved in the work going on in these centers directly or indirectly, but they are there and they are interested, and some are obviously more involved than others. But I don't know any other way we could have gotten our arms around 128 companies to get them to think seriously about what space might have to offer.

Another point. You can maybe judge the effectiveness by how much are companies contributing. The original five CCDSs, we have had a few years to mature them. In fact, these two gentlemen both head up two of those five.

[Slide.]

Let me show you how the funding has gone on these. We used grants to these centers. The first original five CCDSs when they were initiated, the first year was in 1986. We the Government, NASA, through grants put in $4.5 million, and the industry contributed through either money or in-kind a million dollars.

Today in 1989 we are funding the grants at $4.7 million for these five centers and industry is now putting in $13 million. Three to one, and the system is growing and the interest is growing. So we believe we have established a mechanism to begin to entice industry to look seriously at space as an avenue for commercial type applications.

[Slide.]

Let me go a step further. These centers along with our JEA partners have committed to develop payloads to fly into space to test these technologies starting in this past year, in 1988, and the dates that those payloads would be available for us to start a flight program to determine the suitability of this technology as an application. As you can see, 3M is shown prominently, the University of Alabama, Birmingham, the CCDS is there in 1988. As you well know, Dr. Bugg has already flown, in the three Shuttle flights he has flown twice, and they wouldn't let him fly on the military flight, and he would have done that, too, I believe.

But I want to point out his flight, for instance, it shows one flight, but he had seven industries involved in that flight that had samples aboard of his apparatus. Industries like Schering-Plough, Merck Sharpe & Dome, Upjohn, DuPont, Dow Chemical, Kodak and I must have left somebody out. But, anyway, these are the type of industries that are now beginning to seriously look at what we're talking about.

[Slide.]

You will see this go on for two more charts, all the way through the 1995 timeframe. We are developing the payloads to fly in space that industry is wanting to fly. There are some 92 payloads and there are some 250 flight tests associated with this particular program that we have now seen. The next question you're going to ask is can we fly them.

[Slide.]

This is what we are doing this year in 1989. We are going to fly seven times this year, five aboard Shuttles and two flights aboard a sounding rocket program. One sounding rocket was already flown just 2 weeks ago quite successfully. We will be flying again on April the 28th on STS-30, and then we will fly all the rest of the flights that aren't military flights.

Now when we started the year we only had two flights scheduled. Why is that? Because NASA releases its reserve payload weight that it has been holding in case they need reserve about 6 months before the launch, and then you are in a position to take advantage of it. If you have your hardware ready and you have the paperwork through the system you can get aboard fairly quickly.

We are taking advantage of every opportunity to fly in that timeframe, and we believe that we will be able to fly our CCDS's and JEA partners when they need it. And, remember, these people need to fly on a reasonable basis and on a timely basis, and we think we can do that.

Now we have two examples that I want to point out that I think are significant because in order to create a space industry you've got to have markets and products, but you've also got to have infrastructure and you've got to have commercial infrastructure, and you've got to have commercial transportation.

We are now going to try to hook our centers who are working on developing markets and products in with activities that are going in our transportation and our infrastructural companies. For instance, our center at the University of Houston, which is working on epitaxial growth technology requires a wake shield. A wake shield gets them up where they can get on the lee side and reduce the vac to very, very low vacuum levels, and because in space you've got an infinite pumping capacity, this makes this technology practical or otherwise it couldn't be carried out. They are working and collaborating now with SII, Space Industries, Incorporated, to develop this wake shield commercially, in a commercial way.

Second, I wanted to mention the Space Services, Incorporated payload that has just flown on a sounding rocket. The University of Alabama, Huntsville, who is doing crystallography for the most part, work in that particular field, and several other centers for the commercial development of space wanted to fly sounding rocket time in order to look early at some of the technologies that they were pursuing.

Mr. VOLKMER. Sorry, we've got to switch chairs again. I'll be back, Jim.

Mr. ROSE. All right.

Mr. VOLKMER. As I understand, we are going to let all the witnesses testify first and then go to questions. So by the time I'll be back to give some questions to you.

Mr. ROSE. All right.

How are you, Mr. Mineta.

Mr. MINETA. Very well. This is just temporary. [Laughter.]

Mr. ROSE. Well, I'm about to wrap mine up because I know you want to get on and hear what these other people are doing, but I did want to point out that we allowed our center at the University of Alabama, Huntsville, to procure a launch service from a commercial sounding rocket company, a rocket company called SSI, to carry out a flight test of a payload developed by them which is totally private.

This was carried out 2 weeks ago. The whole process took nine months from the time an RFP was put together by our center in Huntsville. Four proposals were received, SSI was selected and six months later we actually had a flight. Hardware developed by the private sector and transportation provided by the private sector. It was fast, efficient and above all it was totally commercial. We think this may be a blueprint for the future.

It just became apparent to myself, I didn't realize this being I was not quite here in 1915, but this country found itself in somewhat of a dismay in that it didn't have an airline or an aircraft industry. We were about to go into World War I and everything that was built and flying was by the French or the English or the Germans. In fact, our Aces that flew, flew either Spads or Sockworth Camels. They didn't fly American airmen. We didn't have any. We didn't have an industry.

This country and the government of this country and the Congress decided we've got to develop an industry. They established the NACA to help develop technology and get it transferred through the use of airmail stamps which they sold for 5 cents apiece. I think they probably paid about $1.25 into the airlines' first stamp to get them going. They created an industry, and I believe that is what we are going to do here.

We've got to create industries in space, commercial industries in space. That's what we are trying to do and I think we are making some progress now. I think we are getting mechanisms in place to make it happen. Certainly 100-and-some companies are beginning to look seriously at markets and products. We certainly have the interest in the transportation industry and we certainly have the interest in companies in the infrastructure world, and we believe we can couple them together in such a way that we can move forward with a very, very sound program.

Now I want to end by just stating that my budget request for the year in my office is—I can't even find where it is here.

Mr. Mineta. It's that small. [Laughter.]

Mr. Rose. $38.3 million, and I'll tell you what's in it. I had some other figures in my written testimony that I wanted to clarify. I show that NASA overall in those activities that directly support commercial space, that in the 1989 budget this year we have $197.4 million. There was a slight error. I had $189 in your paper, but we corrected that. And in the 1990 request NASA is spending $303 million on those activities associated with commercial space.

What that includes is not only my budget, which is directly supporting commercial space, but it also includes Code M's work in funding upper stages and funding private ELVs and in Code E's, our Science Division's work in microgravity research, which is approximately $106 million.

So the total of those elements together would say that the agency is funding things that directly contribute to commercial space development of approximately in the 1990 budget $303 million.

Now the budget that I'm asking for are for those things that I directly implement. They are my funds to do specific things with. That covers for the most part basic grants to our 16 Centers for the Commercial Development of Space. It covers pilot projects like the sounding rocket program, like the vacuum wake shield program and centralizing a launch support operation for our commercial partners at the Kennedy Space Center. It covers the systems engineering and integration support that the JEA and CCDS partners need to have in order to get through NASA's integration procedure to fly. It's a very important thing, how to build hardware, to meet the safety, the interface requirements and what-have-you. We supply that.

We also have certain center projects that go on at our centers primarily in support of common carriers facilities where our CCDSs and JEA partners use facilities and services at the centers in order to carry out their research and their development.

I have said enough, and I know that you are anxious to get me off and hear what is really happening out there in the commercial world. So I'm through, Mr. Chairman.

[The prepared statement of Mr. Rose follows:]

Hold for Release Until
Presented by Witness
April 11, 1989

Statement of

James T. Rose
Assistant Administrator
Office of Commercial Programs
National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science, Space and Technology
House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittee:

Every American is a shareholder in our country's civil space program. Each citizen has contributed to our national investment in space, an investment which, according to a variety of economic studies, has produced a high yield return to our Nation's economy.

It is widely recognized that our space endeavors have provided an impetus for technology development that has improved our lives on Earth while stimulating economic growth. Space technology has enabled the emergence of new and improved products and services for everyday living in such fields as health care, public safety, environmental protection, energy, transportation, and industrial manufacturing, to name just a few.

There is increasing recognition, both here and abroad, that space itself harbors valuable resources that represent a new economic frontier for the space-faring nations of the world. We are at the point where commercial development of space is both a logical next step and a prudent competitive strategy.

The space program, therefore, is making a significant contribution to this Nation's ability to compete in the global marketplace, a contribution that we are working to expand through our cooperative efforts with U.S. industry.

Mr. Chairman, you and the members of this Subcommittee, and many other members of the Congress, are well aware of the economic potential of space. And, because of this, you have assigned NASA the important mission of encouraging the commercial use of space, and stimulating expanded investment and involvement by the U.S. private sector in our Nation's civil space program. NASA's Office of Commercial Programs (OCP), which I head, provides a focus within the agency both for programs supporting the commercial application of existing space technology and the commercial development of space itself.

I am pleased to have this opportunity to discuss with you today these two important programs, and I will begin with a description of our efforts to encourage and support the commercial development of space.

COMMERCIAL DEVELOPMENT OF SPACE

In 1984, the Congress amended the Space Act, directing NASA to "...seek and encourage, to the maximum extent possible, the fullest commercial use of space."

Over the past year, we have worked hard to approach commercial development in a comprehensive way, recognizing both the broad picture and its component parts as we define an overall program to reap the fullest economic benefits from our civil space program. We have categorized and scoped the different types of commercial space activities, assessed the unique requirements and issues affecting growth of each, and developed mechanisms and infrastructures to carry out a comprehensive and aggressive program.

Commercial space activities can be grouped into four general areas: space transportation; information services such as communications, navigation, and remote sensing; new products and services, such as those associated with materials processing in space; and, privately provided space infrastructure.

There are a number of things that government can do to improve the climate and prospects for greater commercial involvement in space. Today, I will be outlining a number of steps that NASA is taking to encourage more fully the resources and talents of the private sector in commercial space endeavors.

a. New Market Development. The issue of commercially developed and privately financed space infrastructure has received a great deal of visibility lately because of its immediacy. NASA is at work refining the criteria and guidelines used for evaluation of infrastructure proposals coming to us from outside the agency, as well as infrastructure projects within NASA that could be candidates for private sector development. This is and will remain an iterative process involving NASA and industry. Establishing appropriate criteria and developing appropriate processes will be necessary to increase NASA's planning capability and to heighten the potential success of the proposed ventures. In addition to performing the initial screening of infrastructure proposals, OCP will continue to be an advocate for the private sector throughout the entire evaluation process.

Although, initially, the U.S. Government may be a predominate user of new goods and services, ultimately, new markets must be developed beyond the U.S. Government. This is a quite different aspect of commercial space which involves the development of new technology by the private sector leading to the provision of new goods and services for commercial markets. These are private sector embryonic product development programs that we expect would require a development period of 5 or more years. But, these are also the activities which hold the greatest potential for economic payoffs to the Nation's economy; therefore, it is vitally important that the government provide the appropriate long-term commitment.

Information services and new products and services will stimulate the growth of private markets and set the pace for commercialization. The other two types of activities, transportation and infrastructure, provide the necessary support and services required for new market success. New market development areas are the future customers for transportation and infrastructure enterprises.

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Therefore, the government must concentrate its assistance and resources on those ventures that can contribute to development of markets for new products, or can be transitioned into the private sector. We believe that we have developed a program with the right balance of thrusts to encourage each of the commercial space areas in a manner appropriate to its unique characteristics and stage of development.

b. OCP Accomplishments. Let me highlight some of the more important OCP accomplishments that have taken place over the past year:

(1) We have identified areas of our organization where skills and talents needed to be augmented, due either to departure of personnel or changing needs and requirements. We have been successful in bringing on board people to meet these requirements, and we have shifted some organizational responsibilities in order to meet changing requirements.

(2) Recognizing that we now have a need to address financial implications of the ever increasing commercial projects and proposals, we have put in place a structure to accomplish this. In developing this capability, we are drawing on the skills of both our government employee staff and a number of private sector experts from the business and financial communities.

(3) We have established the Commercial Programs Advisory Committee (CPAC) to help determine a national course for commercial development.

(4) We have neared completion of a long-range strategic plan with private sector assistance.

(5) An Operations Management Council for the Centers for the Commercial Development of Space (CCDS) to improve their effectiveness has been established.

(6) We have developed a flight plan to maximize transportation opportunities for CCDS payloads and Joint Endeavor Agreement (JEA) partners.

(7) We have drafted a Commercial Space Infrastructure Policy, Criteria, and Procedures document for evaluating industry proposals.

(8) Six new NASA/industry agreements have been signed, including the first for the commercial use of Shuttle external tanks.

(9) Eight potential new JEA partners have been identified.

At this time, I would like to discuss some of our accomplishments in greater detail:

c. Involving the Private Sector in the Planning Process. As independent national economies merge into an integrated global economy, government policies and industry practices can no longer operate in the "splendid isolation" which has been our tradition. There are those who contend that since space will always be there, there is no reason to hurry the development of commercial applications. When there is anything worthwhile to commercialize, industry will do it. Therefore, government should stay out of the way.

In the face of foreign competition, the pace for developing commercial space applications by the private sector in the United States does matter. For U.S. industry to compete against foreign firms receiving direct or indirect government support, appropriate cooperation between the public and private sectors in this country is essential.

There is no question that commercial developments in space will be done by the private sector; therefore, the private sector must be involved in defining what needs to be done to stimulate their involvement. My office has taken two major actions to bring industry's views into focus:

(1) Commercial Programs Advisory Committee (CPAC). First, we asked 18 Chief Executive Officers and university presidents to join us in forming CPAC. CPAC is represented by large and small firms from many industries, including aerospace, nonaerospace, and financing, and offers a diverse and wide-ranging perspective. Mr. Edward Donley, Chairman, Executive Committee,

Air Products and Chemicals, Incorporated, is the CPAC Chairman. CPAC is a standing committee of the NASA Advisory Council which will provide NASA with continuing advice on the proper roles and responsibilities of government and industry in commercial development of space.

For this Subcommittee to appropriately guide NASA and the Nation in our commercial development effort, they must be familiar with all segments of the industry. NASA has expended considerable effort to provide CPAC with the background information they need for their informed participation. We used professionally produced video tapes to condense over 200 hours of interviews with 64 commercial space experts into 5 hours of informative discussion of the issues.

(2) Strategic Planning. Second, we contracted with the American Institute of Aeronautics and Astronautics (AIAA) to conduct a study of issues and potential objectives associated with commercial development of space. AIAA formed a steering committee consisting of senior level, private sector managers with considerable experience in the commercial space environment. The AIAA work represents inputs of over 90 industry representatives in 7 working groups, and will assist CPAC in articulating industry concerns and proposing recommendations for NASA and the Nation. The CPAC report and recommendations for national consideration is expected to be released during June 1989. The recommendations can then be incorporated into NASA's comprehensive strategic plan for encouraging commercial development of space over the next 25 years.

d. Supporting the Development of New Products and Services. The development of new products and services, especially those involving materials processing or life sciences, requires long-term commitment. However, without these new products and services, other commercial space industries, such as transportation and infrastructure, will not be realized. A number of barriers, such as the upfront costs of accessing space, can be prohibitive for firms conducting research and development that may or may not yield returns years in the future. NASA has developed two programs targeted toward overcoming these obstacles to market development:

(1) Joint Endeavor Agreements (JEA). For those companies that have committed resources and are in active product development stages, we offer the JEA. The JEA is a cooperative working arrangement which gives these firms access to NASA facilities and services and, in return, NASA receives the right to use the data which emanates from the commercial research efforts for its own use. We currently have 5 active JEA's with over 70 identified flight requirements. Of note is the recent success of a JEA experiment from the 3M Corporation flown on STS-26. The company is investigating the effects of low gravity on the behavior of certain organic materials.

New potential JEA partners have been identified for joint ventures this year. The following list is an indication of the breadth of the JEA Program and of the types of new markets and products emerging:

(a) Corabi International Telemetrics, Incorporated, has signed an agreement to explore a telemedical/telescience workstation for Space Station Freedom.

(b) A large oil firm is exploring the use of remote sensing systems to locate and survey nonrenewable resources.

(c) A small manufacturer of high temperature superconducting materials wants to explore commercial applications and possible space-based processing of its materials. To date, this company's materials have demonstrated superconducting characteristics superior to previously reported materials.

(d) A small technology firm is developing high efficiency photovoltaic systems, or solar cells, with a new concept that could potentially double the efficiency of presently used systems.

(e) A large utility firm is interested in commercially supplying auxiliary power in space for orbital systems.

(f) A small, value-added company has developed a concept of using hand-held photography in space to produce commercially viable photographic products.

It is important to remember that once a company, such as these and our other JEA partners, commit to long-term research efforts, they must proceed according to internal planning schedules. It is essential for NASA to have the ability to support in a timely manner these important development efforts.

(2) Centers for the Commercial Development of Space (CCDS). For those firms not in position to commit to long-term investment, NASA has established the CCDS Program. The CCDS's are consortia of university, industry, and government involved in early research and testing stages of potentially viable products or services. Through the CCDS's, NASA provides the financial backing needed for the applied technology phase, while academia and industry provide the imagination and the "bottom line" market approach necessary to bridge the gap between applied research and commercial application.

We believe this approach will ultimately result in large scale industry involvement in developing space-related technologies. These industry-driven technologies could, in turn, lead to a broad base of new markets and services. We are excited about the progress CCDS's are making. The 16 CCDS's currently involve the active participation of 48 universities and 128 companies. The success of CCDS's is demonstrated in the following achievements for this past year:

(a) The CCDS Management Operations Council was established to involve CCDS Directors in NASA planning. This coordinating body will help CCDS's share information, develop an overall program direction, and work collectively with NASA.

(b) An experiment on protein crystals grown in space was successfully flown on STS-26 by the Center for Macromolecular Crystallography at the University of Alabama-Birmingham. A second flight on STS-29, just completed recently, involved the conduct of further experiments with protein crystals whose structure can be analyzed and this will contribute to the eventual design of powerful new drugs to fight cancer, high blood pressure, organ transplant rejection, rheumatoid arthritis, and many other diseases.

(c) A commercially provided sounding rocket service has been selected by the Consortium for Materials Development in Space, a CCDS affiliated with the University of Alabama-Huntsville, to launch a payload of five experiments on materials processing in space this spring. This launch was successfully carried out by Space Services, Incorporated, on March 29, 1989.

(d) Up to 290 flight tests are being contemplated to carry out a flight technology program on 58 different materials or systems of interest now under development at 12 of our CCDS's.

As the seven CCDS's initiated in 1987 become more firmly established, the CCDS Program will become even more active. Through these research consortia, we can achieve two, sometimes conflicting, objectives. On the one hand, because private capital is at risk, CCDS's take a "market-driven" approach to innovation, emphasizing production requirements and market demands. On the other hand, CCDS's have the resources and the time to invest in the lengthy transition from public research to private development, because government seed money is provided. When the CCDS industrial partners decide that potential returns warrant long-term commitments of resources, they may then pursue a JEA arrangement. This working partnership can help ensure that U.S. commercial space research will successfully compete in the international environment.

e. Evolution of the OCP Flight Program. Formation of consortia such as CCDS's, and establishment of JEA partnerships will amount simply to intellectual exercises if the resulting projects do not have access to space in a timely manner. OCP is developing a flight plan to meet these anticipated needs. We have been allocated 31 percent of the secondary payload space on non-Department of Defense flights for commercial use. It is important to ensure that this space is used judiciously, and is of optimum benefit to industry.

The first step in the development of such a plan is to develop realistic requirements. Working with CCDS's, we have identified real, near-term flight requirements and are putting in place those policies, plans, systems, and organizations to systematically develop a realistic flight program schedule for the future.

Using these requirements as a base, we can extrapolate the requirements to meet anticipated new JEA's, and future potential commercial enterprises. The system OCP has initiated is working and is exemplified by the fact that a year ago there were only 10 specifically identified CCDS payload flight opportunities and, as of today, we have identified 150 of 290 eventually contemplated.

We are using our expertise to assist CCDS's and JEA partners in developing hardware that both meets NASA requirements and is designed in such a way as to gain quick access to the Shuttle should openings in the manifest occur late in the planning cycle. We have been successful in this also. For example, in CY 1989, we anticipated having opportunities to fly two commercial payloads, but now, because we have been able to assist our commercial partners in being able to take advantage of opportunities, may be able to fly up to seven payloads. Our near-term and strategic planning efforts are designed to ensure that developing space enterprises fly in a timely manner through a well defined and structured flight schedule that supports maturing industries regardless of their desired access to space mode.

This has in part been made possible through the development of new management tools. We have developed several management tools to make this new frontier more easily understood by the CCDS's and the private sector. These tools include the following: an STS Carrier Handbook of characteristics of STS compatible carriers; a Catalogue for Commercial Users which is a national inventory of resources available for commercial space users; videos and other documents that can be used as tutorials; and, documentation for preflight opportunities and the development of screening criteria and mechanisms that serve as guidelines for all commercial payloads.

f. Other Significant Activities. NASA is working to stimulate the market for value-added services derived from remote sensing technology. By developing the markets, requirements for new instruments and platforms will be driven by need. Research in commercial development of remote sensing technology is being led by two CCDS's at the Ohio State University and the Institute for Technology Development, near the recently established Earth Observations Support Office at NASA's John C. Stennis Space Center. Through improvements in sensor technology and data handling and interpretation techniques, the CCDS's hope to achieve a real-time satellite mapping capability. OCP is also jointly sponsoring 20 research projects in scientific and commercial remote sensing with the Office of Space Science and Applications.

In August 1988, NASA and SPACEHAB, Incorporated, signed a Space Systems Development Agreement for launch of SPACEHAB's commercially developed and manufactured module. SPACEHAB is a pressurized metal cylinder that fits in forward portion of the Shuttle payload bay and connects to the crew compartment through the orbiter airlock. It increases the pressurized working space on the orbiter by 1,000 cubic feet. Commercial ventures and sponsored research requiring man-tended access to the environment of space will be the primary target market for this venture. NASA has committed to six Shuttle flights for SPACEHAB modules beginning in 1991 and has manifested SPACEHAB on five flights: STS-51 (November 1991), STS-61 (September 1992), and STS-71 (January 1993), STS-79 (January 1994), and STS-86 (July 1994).

In addition to signing three new facilities use agreements with expendable launch vehicle (ELV) firms this year, NASA is trying to bolster the transportation industry by enhancing the development of the Nation's commercial sounding rocket capability. NASA is encouraging the CCDS at the University of Alabama-Huntsville to commercially solicit sounding rocket launch services for

CCDS experiments. This activity is not only supporting the launch industry, but also new product development. We are continuing to examine other mechanisms for delivering small payloads into low-Earth orbit.

In June 1988, we issued a Request for Expressions of Interest for private sector use of expended Shuttle external tanks. Ten organizations responded with proposals. OCP conducted a preliminary screening of these proposals and, as a result, three proposals remained for further technical, safety, and business evaluations. The Office of Space Flight is currently performing these detailed reviews. We also signed a Memorandum of Agreement in December 1988 with the University Corporation for Atmospheric Research, granting them use of space within five designated external tanks, on a suborbital basis.

And last, but certainly not least, we have initiated a number of studies to determine the impact of transportation costs on entry decisions by the private sector. If the cost of getting into space is prohibitive, companies will not make the decision even to start a research program. We need appropriate flexibility in our pricing policies so that we do not discourage entering companies from even beginning their research. It is also necessary to insure that government-offered services do not preclude or compete against commercial sector initiatives.

g. FY 1990 Commercial Use of Space Budget Request. NASA's direct efforts to encourage the commercial development of space is represented by a FY 1989 budget of $189 million and a FY 1990 request of $312 million excluding the ACTS. These monies, in addition to the OCP budget, include funding for research in microgravity sciences, research and hardware in the Office of Space Science and Applications, and purchases of commercial launch services in the Office of Space Flight.

The OCP budget request of $38.3 million for FY 1990 Commercial Use of Space is to fund those activities for which my office has the direct implementation responsibility. The FY 1990 OCP Commercial Use of Space request will be used to carry out the following:

(1) the basic CCDS grants and necessary augmentations;

(2) pilot projects, including CCDS commercially purchased sounding rocket services, commercially developed space processes, and centralized launch support operations for CCDS and JEA payloads;

(3) system engineering and integration support for CCDS and JEA payloads in OCP and the National Space Transportation System;

(4) optional service support for Space System Development Agreement customers; and,

(5) NASA Center projects including remote sensing application studies, the sharing of needed Center facilities and services for commercial partners, and supply of common carriers for selected payloads.

TECHNOLOGY UTILIZATION

Increasing emphasis is being placed on the transfer of government-funded technology to the private sector as a way of improving the Nation's competitive posture. Recent legislation and executive orders have directed federal agencies to increase their efforts in moving new technologies to industry. We have responded by conducting a thorough review of our Technology Utilization Program and incorporating the results into a new strategic plan. The plan will be used as a guideline for the effective transfer of NASA and NASA-sponsored technology.

NASA also was the first federal agency to formally distribute its patent royalty income as required by P.L. 99-502. On June 3, 1988, checks totaling $56,944 were mailed to 35 present and former NASA employee-inventors. The checks paid the inventors' share of NASA's patent royalty income received between the effective date of the Federal Technology Transfer Act of 1986 (October 20, 1986) and December 31, 1987. In addition, NASA is in the process of distributing $61,000 in royalties received during the past year.

a. Dissemination. A major element within the technology transfer program is the **Tech Briefs** publication. Through the publication, descriptions of NASA research innovations are currently distributed to approximately 200,000 domestic subscribers annually. The commercially produced magazine has published nearly 13,000 new technology reports since its beginning and has generated more than 1.5 million requests for more detailed information. The number of issues published annually is increasing from 10 to 12 per year because of increased interest.

NASA's annual **Spinoffs** publication continues to report NASA's many space technology spinoffs to the private sector. More than 600 items have been reported since its inception. The Spinoff Hall of Fame, sponsored and managed by the U.S. Space Foundation, was officially opened in Colorado Springs last year. Five NASA technologies were selected for induction. Further NASA technologies are scheduled for selection into the Hall of Fame during the spring of this year.

NASA is currently involved in a study to assess the economic impact of some of the spinoffs and applications reported in the **Spinoff** magazine. Tangible statistics on the impact of technology transfer are often difficult to measure or summarize. However, researchers have traced nearly 350 applications publicized in the annual reports and have obtained estimated revenues and cost savings that may be attributed in part or in whole to NASA programs. These NASA spinoffs have resulted in economic benefits from contributions to sales or savings in the billions since 1978. The study is still in progress, but the findings thus far strongly illustrate the importance of technology transfer. The second phase of this study, now underway, is attempting to define the total environment of the more than 20,000 applications which have been reported to exist, and it is our hope to quantify the economic benefits within a period of 12 months thereafter.

b. Industrial Applications Centers (IAC) and Affiliates. NASA supports a nationwide network of IAC's whose over 10,000 yearly industry clients have access to nearly 100 million scientific and technical documents in the NASA data bank and over 400 other computerized data bases. IAC affiliates are geographic extensions, similar to branch offices, of NASA IAC's and work primarily through state university-based industry technical assistance centers, small business assistance centers, and similar organizations. Currently 40 states have such affiliates linked to NASA's technology transfer infrastructure. Discussions are currently underway in seven additional states to establish linkages with the NASA network.

NASA has entered into a blanket agreement with the Federal Laboratory Consortium (FLC) that links the IAC network with approximately 500 FLC laboratories. Through this agreement, small and large business firms can use access points within their home states to determine availability of federal technology relative to their needs. NASA is continuing to work to further expand private sector access through other federal- and state-supported industry assistance activities, including the more than 500 Small Business Development Centers, Economic Development Agency Centers, and the proposed Department of Commerce Hollings Centers.

c. AdaNET Software Repository. To further strengthen and enhance technology transfer activities, NASA is continuing the planning and implementation of the AdaNET Program. The AdaNET Software Repository is intended to be a self-supporting commercial organization to provide users of Ada with information sharing and depository services. It will operate on a for-profit basis recovering cost through charges levied for services offered. Establishing an outlet for Ada software will benefit the private sector by giving added capability for solving many industrial and manufacturing problems. Access will be available electronically through network services provided under commercial agreements.

The AdaNET Program is currently in Phase II of its implementation plan which is to develop a revenue support structure for recovery of initial costs, a model license agreement for use with owners of Ada technology and for consumers, and organizational documents and governing policies. In Phase III of the project, subject to funding availability, the approved plan will be implemented. AdaNET is targeted to become self-sustaining through client income by 1991.

d. Technology Applications. Application projects were first established to provide direct NASA assistance in promoting secondary use of aerospace technology. Problems are identified by private firms or other organizations and potential solutions through NASA technology are studied. There are currently over 80 projects underway at 9 NASA field installations. In FY 1990, NASA will continue to broaden applications team responsibilities for brokering industrial client needs.

Examples of FY 1989 and FY 1990 technology projects include the following three examples:

(1) An instrument and technique for measuring the depth of skin burns. This project resulted from an observation that the burn damaged and healthy skin/tissue interface produces an ultrasonic reflection. Since the medical treatment differs substantially between second and third degree burns, and since the determination of the degree of a burn is now largely subjective and prone to error, the project was initiated to fill a need for a quantitative method for determining the depth of burns.

(2) A low-powered laser instrument which can precisely map the cornea of the human eye and provide accurate data for use by a surgeon during radial keratectomy procedure. The project involves the development of a rapid scanning system that would use visible light and would provide a raster scan pattern of the cornea. A small desktop computer would be used to synchronize the scanner and electronics to record data and plot the contour in real time with an accuracy of several microns in depth. The data would then be presented as a contour map.

(3) The Stirling engine, an external combustion engine which, when compared with conventional internal combustion engines, offers a number of unique advantages. It is a high torque engine that operates at a constant speed. It uses one spark plug, needs no muffler, emits no noxious gases, and can use any kind of fuel. In addition to use in vans and trucks, it is also under consideration for irrigation pumping and mobile processing in agriculture, drying processes in the lumber industry, and for use on trawlers, dredges, and shrimp boats in the fishing industry. Given its many advantages and its versatility, the Stirling engine may have significant impact on the U.S. transportation and processing industries.

A multiyear, multiphase demonstration program was created by an industry/government team to obtain early operation and performance data; evaluate integrity, reliability, and durability; and accelerate the development of the Stirling engine. In Phase I, a first generation Mod I Stirling engine was operated for 1,300 hours and nearly 7,000 miles using unleaded gasoline and JP-4 aircraft fuel in an Air Force van. This operational experience with the Stirling-powered van is providing the first "real world" data for transportation applications. No problems were identified.

e. FY 1990 Technology Utilization Budget Request. In FY 1990, the budget request for the Technology Utilization Program is $22.7 million, which money will be used to accomplish the following activities:

(1) broadening of application projects to assist NASA IAC's in bringing together industrial client problems with existing aerospace technologies, leading to project definition and industry-driven cooperative projects, thus enhancing the productivity and competitive posture of U.S. industry;

(2) improving the capability of the technology utilization offices at the NASA field installations to increase the level of technology transfer activities by means of a microcomputer-based system that efficiently stores data and facilitates timely access to new technologies developed in NASA's R&D programs. This network, the Technology Utilization Network System (TUNS), completes the linkage of the NASA technology utilization field installation

offices, the NASA Software Repository (COSMIC), the NASA Scientific Technical and Information Facility (STIF), and IAC's to provide a quicker distribution of new technologies that has previously been possible;

(3) increasing new technology identification, evaluation, reporting, and more efficiently packaging these new technologies for publications, thereby stimulating increased industrial interest and participation in NASA's Technology Utilization and Commercial Use of Space Programs;

(4) increasing the utilization and expanding the role of NASA's IAC's (industrial outreach agents) as a unique network to serve as NASA's surrogate in aligning U.S. industrial interests in space commercialization as well as opportunities for terrestrial commercialization of advanced technologies derived from NASA's R&D programs; and,

(5) promoting awareness of NASA's Technology Utilization Program and resources available to the public and private sectors through a broad array of program materials, seminar, and conferences. Industrial outreach will be expanded by efforts to identify additional nonaerospace users of NASA's technologies.

This concludes my prepared remarks, Mr. Chairman. I would be pleased to respond to questions.

National Aeronautics and
Space Administration

Washington, D.C.
20546

Biographical Data

JAMES T. ROSE
Assistant Administrator for Commercial Programs
National Aeronautics and Space Administration
Washington, DC

James T. Rose became Assistant Administrator for Commercial Programs on October 5, 1987. This office provides a focus for and facilitates efforts within NASA to expand U.S. private sector investment and involvement in civil space-related activities and supports innovative research by small business firms.

Prior to his current assignment, he was Director for Space in NASA's Office of Aeronautics and Space Technology. From 1976 to 1986 he was Director of McDonnell Douglas' Electrophoresis Operations in Space program. He also previously held a series of key positions at the McDonnell Douglas Astronautics Company from 1964 to 1974.

Mr. Rose began his career at NASA's Langley Research Center in 1957 as a research engineer supporting the Vanguard Program experiments. He was assigned to NASA's Space Task Group in 1959 and was asked in 1962 to head the Manned Spacecraft Center's Mission Planning Office for all of the Gemini flights.

He returned to NASA in 1974 as Director of Space Shuttle Engineering in the Office of Spaceflight. Leaving the agency to head McDonnell Douglas' space manufacturing initiatives, he again rejoined NASA in January 1987 as Director of the Space Flight/Space Station Integration Office before being appointed to his present position.

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October 1987

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SPECTRUM OF PRIVATIZATION/ COMMERCIALIZATION ACTIVITIES

TYPE	TYPICAL EXAMPLES
INFORMATION SYSTEMS	• COMMUNICATIONS SATELLITES • REMOTE SENSING
TRANSPORTATION	• EXPENDABLE LAUNCH VEHICLES • SOUNDING ROCKETS
INFRASTRUCTURE	• COMMERCIALLY DEVELOPED SPACE FACILITY • SPACEHAB • PRIVATELY DEVELOPED UPPER STAGES
NEW PRODUCTS AND SERVICES	• PHARMACEUTICALS • CRYSTALS • GEOSTAR

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CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE (CCDS)

TECHNICAL DISCIPLINE	# INVOLVED	CCDS'S
1. AUTOMATION AND ROBOTICS	2	• UNIV. OF WISCONSIN, MADISON, WI • ENVIRON. RESEARCH INST. OF MICHIGAN, ANN ARBOR, MI
2. LIFE SCIENCES	3	• UNIV. OF COLORADO, BOULDER, CO • PENN STATE UNIV., UNIVERSITY PARK, PA • UNIV. OF ALABAMA, BIRMINGHAM, AL
3. MATERIALS PROCESSING IN SPACE (MPS)	5	• BATTELLE, COLUMBUS, OH • UNIV. OF ALABAMA, HUNTSVILLE, AL • VANDERBILT UNIV., NASHVILLE, TN • CLARKSON UNIV., POTSDAM, NY • UNIV. OF HOUSTON, HOUSTON, TX
4. REMOTE SENSING	2	• INST. FOR TECH. DEVELOP., STENNIS SPACE CENTER, MS • OHIO STATE, COLUMBUS, OH
5. SPACE POWER	2	• AUBURN UNIV., AUBURN, AL • TEXAS A&M UNIV., COLLEGE STATION, TX
6. SPACE PROPULSION	1	• UNIV. OF TENNESSEE SPACE INSTITUTE, TULLAHOMA, TN
7. SPACE STRUCTURES AND MATERIALS	1	• CASE WESTERN RESERVE UNIV., CLEVELAND, OH

SUMMARY: THERE ARE CURRENTLY SEVEN TECHNOLOGY DISCIPLINES REPRESENTED IN THE CCDS PROGRAM. THE MAJORITY OF THE CCDS'S ARE CONDUCTING RESEARCH IN MPS.

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CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE
UNIVERSITY AFFILIATES

48 UNIVERSITIES

AKRON UNIVERSITY
CASE WESTERN RESERVE UNIVERSITY
CLARKSON UNIVERSITY
CLEVELAND UNIVERSITY
OHIO STATE UNIVERSITY
WASHINGTON STATE UNIVERSITY
WORCESTER POLYTECHNIC
PENNSYLVANIA STATE UNIVERSITY
UNIVERSITY OF MAINE
MURRAY STATE UNIVERSITY
FLORIDA STATE UNIVERSITY
MONTANA STATE UNIVERSITY
UNIVERSITY OF SOUTHERN MISSISSIPPI
PURDUE UNIVERSITY
UNIVERSITY OF ARKANSAS
UNIVERSITY OF ALABAMA - HUNTSVILLE
UNIVERSITY OF ALABAMA - TUSCALOOSA
UNIVERSITY OF FLORIDA - GAINESVILLE
MISSISSIPPI STATE UNIVERSITY
UNIVERSITY OF ARIZONA
GEORGIA INSTITUTE OF TECHNOLOGY
UNIVERSITY OF CALIFORNIA - RIVERSIDE
UNIVERSITY OF CHICAGO
UNIVERSITY OF WASHINGTON - SEATTLE
UNIVERSITY OF TEXAS - GALVESTON
UNIVERSITY OF MISSISSIPPI
UNIVERSITY OF MICHIGAN
MICHIGAN STATE UNIVERSITY
UNIVERSITY OF CALIFORNIA - BERKELEY
ALABAMA A&M UNIVERSITY
RENSSELAER POLYTECHNIC INSTITUTE
UNIVERSITY OF ILLINOIS - URBANA
UNIVERSITY OF WISCONSIN - MADISON
KANSAS STATE UNIVERSITY
UNIVERSITY OF UTAH
UNIVERSITY OF COLORADO - DENVER
FLORIDA A&M UNIVERSITY
UNIVERSITY OF BUFFALO
UNIVERSITY OF SOUTH CAROLINA
UNIVERSITY OF TENNESSEE SPACE INSTITUTE
AUBURN UNIVERSITY
PRAIRIE VIEW A&M UNIVERSITY
LAMAR UNIVERSITY
UNIVERSITY OF TEXAS AT ARLINGTON
COLUMBIA UNIVERSITY
ARIZONA STATE UNIVERSITY
JEFFERSON MEDICAL COLLEGE
COLORADO STATE UNIVERSITY

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PRELIMINARY LISTING OF CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE CORPORATE AFFILIATES

128 CORPORATE

3M
ABBOT LABORATORIES
ALCOA
ALLIED SIGNAL
ALZA
AMOCO CHEMICALS CORPORATION
APPLE COMPUTERS
ARMCO, INC.
ARTHUR D. LITTLE
ASTRONAUTICS CORP. OF AMERICA
AT&T
BALL AEROSPACE
BARNES ENGINEERING
BEAVER DAM EMERGING GROWTH
BEND RESEARCH
BIOCRYST
BOEING AEROSPACE COMPANY
CABOT CORP.
CENTRAL BIOMEDIA
CHROMATEM
COLUMBINE VENTURE FUND
COULTER
CREARE, INC.
CSAT
DANTEC ELECTRONICS
DEERE AND COMPANY
DELCO
DEVELOPMENTAL PLANNING & RESEARCH
DIGENE
DOW CHEMICALS
DUVAL COMPOSITES, INC.
E-SYSTEMS, INC.
E.I. DuPONT
EAGLE-PICHER, INC.
EASTMAN KODAK
EDISON POLYMER INNOVATION
EG&G
ELECTRIC POWER RESEARCH INSTITUTE
ELECTRO-OPTEK
ELECTROPORE, INC.
ELI LILY
ENDOTRONICS
ENGLEHARD CORP.

ENTECH, INC.
ESRI
FAIRCHILD
FORD AEROSPACE
FOSTER MILLER
FRED FERNSLER
FREEPORT MCMORAN
FRONTIER RESEARCH
GAMMEX, INC.
GELMAN SCIENCES
GENENTECH, INC.
GENERAL DYNAMICS
GENERAL ELECTRIC
GENERAL MOTORS
GEOSPECTRA, INC.
GOODYEAR
GRUMMAN CORP.
GTE
GULF STATE UTILITIES
HANFORD ENGINEERING LABORATORIES
HERCULES
HUTSON FERTILIZER
IATROMED
IBM ALMADEN
II-VI, INC.
INDUSTRIAL TECHNICAL INSTITUTE
INSTRUMENTS S.A., INC.
INTERGRAPH
INTERNATIONAL PAPER
ITA
JOHNSON CONTROLS, INC.
KMS FUSION
LEMONT SCIENTIFIC COMPANY
LOCKHEED
LUNAR RADIATION
MADISON KIPP, INC.
MARTIN MARIETTA AEROSPACE
MASSCOMP
MASTER BUILDERS, INC.
MAXWELL LABORATORIES
McDONNELL DOUGLAS CORP.
MERCK, SHARPE & DOME
METROLASER

MICKLEY & ASSOCIATESPEPCO
MONOCLONAL PRODUCTION
OCEANROUTES
OPTRA
PALEN FARMS, INC.
PEPCO
PERKIN-ELMER
PHILLIPS PETROLEUM
PHYTO FARMS OF AMERICA
PIERRE FABRE MEDICAMENT
PIERSON PRODUCTS, INC.
PPG INDUSTRIES, INC.
PRECISION SCIENTIFIC
PROCTOR & GAMBLE
QUANTUM TECHNOLOGIES
ROCKETDYNE
ROCKWELL INTERNATIONAL
SATURN CORP.
SCHERING CORP.
SCIENTIFIC ENTERPRISES
SEVRAIN TECH, INC.
SILICON SENSORS
SMITH, KLINE & BECKMAN
SNAP-ON-TOOLS
SOLAR ENERGY RESEARCH INSTITUTE
STRATEGY DEVELOPMENT
SUNDSTRAND CORP.
SUPELCO
SYMBOLICS, INC.
TECHNION, INC.
TECTRONIX
TELEDYNE BROWN ENGINEERING
TELEDYNE WAH CHANG
TRANS-TEMP
TRW
UPJOHN
VERSATEC
WATER TECH CORP.
WESTINGHOUSE
WYLE LABORATORIES
ZETACHRON
ZYNAXIS CELL SCIENCE

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CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE (CCDS) AND JOINT ENDEAVOR AGREEMENTS PLANNING REQUIREMENTS

ORGANIZATION	AVAILABILITY	NO. OF FLIGHTS	ACTIVITY
3M	1989	2	POLYMER MORPHOLOGY
UNIVERSITY OF ALABAMA - HUNTSVILLE (UAH)	1989	2	MATERIALS PROCESSING ROCKET FLIGHTS
ROCKWELL	1989	2	FLOAT ZONE PROCESSING
BATTELLE	1989	5	MEMBRANE FORMATION
BATTELLE	1989	5	INORGANIC CRYSTAL GROWTH FROM SOLUTION
UNIVERSITY OF ALABAMA - BIRMINGHAM (UAB)	1989	7	PROTEIN CRYSTAL GROWTH BY VAPOR DIFFUSION
PENN STATE	1989	2	SKELETAL EFFECTS #1 AND #2
UNIVERSITY OF COLORADO	1989	2	BIOPROCESSING MATERIALS DISPERSION APPARATUS
UNIVERSITY OF COLORADO	1989	2	HIGHER ORDER PLANT GROWTH
3M	1990	2	PHYSICAL VAPOR TRANSPORT/THIN FILMS
AUBURN	1990	6	FUEL CELL
AUBURN	1990	6	POWER CONVERTER
BATTELLE	1990	3	POLYMER MEMBRANES
BATTELLE	1990	3	POLYMER COMPOSITES
BATTELLE	1990	3	DOPED NON-LINEAR OPTIC SUBSTRATES
CASE WESTERN	1990	3	LIMITED DURATION SPACE ENVIRONMENT COMPOSITE MATERIALS EXPOSURE
PENN STATE	1990	2	DRUG DELIVERY SYSTEMS
UNIVERSITY OF COLORADO	1990	4	BIOPROCESSING FLUIDS EXPERIMENT I
UNIVERSITY OF COLORADO	1990	4	BIOPROCESSING FLUIDS EXPERIMENT II
UNIVERSITY OF COLORADO	1990	2	LOSSES IN MICROGRAVITY
UAH	1990	1	MATERIALS PROCESSING MULTIPLE INVESTIGATIONS
3M	1991	2	PHYSICAL VAPOR TRANSPORT/THIN FILMS
BOEING	1991	3	CRYSTALS BY VAPOR TRANSPORT

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CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE (CCDS) AND JOINT ENDEAVOR AGREEMENTS PLANNING REQUIREMENTS (CONTINUED)

ORGANIZATION	AVAILABILITY	NO. OF FLIGHTS	ACTIVITY
ERIM	1991	6	PLANT CELL GROWTH DYNAMICS
ERIM	1991	6	MICROGRAVITY ACTUATOR SYSTEMS TEST
PENN STATE	1991	2	CELL SEPARATIONS
PENN STATE	1991	2	NON-INVASIVE BONE DENSITOMETRY
UNIVERSITY OF HOUSTON	1991	1	MOLECULAR BEAM EPITAXY OF THIN FILM MATERIALS
TEXAS A&M	1991	1	MICRO HEAT PIPE EVALUATION
UNIVERSITY OF ALABAMA - HUNTSVILLE (UAH)	1991	1	MATERIALS IN HYPERTHERMAL ATOMIC OXYGEN
UAH	1991	3	PHYSICAL VAPOR TRANSPORT CRYSTAL GROWTH
UAH	1991	3	CRYSTALS & FILMS, POLYMERS, ELECTRODEPOSITION
VANDERBILT	1991	5	FLOATING ZONE PROCESSING OF SEMICONDUCTOR-METAL EUTECTICS
3M	1992	2	MATERIALS PROCESSING FOLLOW-ON INVESTIGATIONS
INSTRUMENTATION TECHNOLOGY ASSOCIATES	1992	2	MATERIALS PROCESSING MULTIPLE INVESTIGATIONS
INTERNATIONAL SPACE CORPORATION	1992	8	NORMAL FREEZING FURNACE
BATTELLE	1992	3	HYDROTHERMAL INORGANIC CRYSTAL GROWTH
CASE WESTERN	1992	4	EXTENDED DURATION SPACE ENVIRONMENT COMPOSITE MATERIALS EXPOSURE
CLARKSON	1992	2	NON-LINEAR OPTICAL CRYSTAL GROWTH
CLARKSON	1992	2	LIQUID ENCAPSULATED MELT ZONE
CLARKSON	1992	2	CHEMICAL VAPOR TRANSPORT
TEXAS A&M	1992	1	MICROWAVE POWER TRANSMISSION PHASE I
UNIVERSITY OF ALABAMA - BIRMINGHAM	1992	6	PROTEIN CRYSTAL GROWTH/ADVANCED SYSTEM
UNIVERSITY OF COLORADO	1992	3	BLOOD RHEOLOGY, LYMPHATICS, BONE DYNAMICS
UNIVERSITY OF COLORADO	1992	3	GENERIC BIOPROCESSING APPARATUS
UNIVERSITY OF COLORADO	1992	3	MICRO-ORGANISMIC REACTOR
UNIVERSITY OF COLORADO	1992	2	CENTRIFUGAL FLUIDS MANAGEMENT

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CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE (CCDS) AND JOINT ENDEAVOR AGREEMENTS PLANNING REQUIREMENTS (CONTINUED)

ORGANIZATION	AVAILABILITY	NO. OF FLIGHTS	ACTIVITY
UNIVERSITY OF HOUSTON	1992	1	MOLECULAR BEAM EPITAXY OF HETEROSTRUCTURES
UNIVERSITY OF HOUSTON	1992	1	CHEMICAL BEAM EPITAXY OF HETEROSTRUCTURES
UNIVERSITY OF ALABAMA - HUNTSVILLE	1992	3	CRYSTALS, MONOMERS, DEPOSITION AND SEPARATION
UNIVERSITY OF WISCONSIN	1992	2	HYDROPONICS SYSTEMS
UNIVERSITY OF WISCONSIN	1992	6	ROBOTIC MANIPULATOR
VANDERBILT	1992	2	DIRECTIONAL SOLIDIFICATION OF ALLOYS
VANDERBILT	1992	2	OXIDE STRENGTHENED HIGH TEMPERATURE ALLOYS
3M	1993	2	MATERIALS PROCESSING FOLLOW-ON INVESTIGATIONS
BATTELLE	1993	2	FLOAT ZONE CRYSTAL GROWTH
CLARKSON	1993	1	DIRECTIONAL SOLIDIFICATION
ERIM	1993	6	BIOREACTOR DESIGN TEST
UNIVERSITY OF HOUSTON	1993	1	MOLECULAR BEAM EPITAXY OF THIN FILM HIGH TEMPERATURE SUPERCONDUCTORS
3M	1994	2	MATERIALS PROCESSING FOLLOW-ON INVESTIGATIONS
3M	1994	7	MATERIALS PROCESSING CARGO BAY ACTIVITIES
CASE WESTERN	1994	2	LONG DURATION EXPOSURE OF COMPOSITE MATERIALS
TEXAS A&M	1994	1	MICROWAVE POWER TRANSMISSION PHASE II
3M	1995	2	MATERIALS PROCESSING FOLLOW-ON INVESTIGATIONS
3M	1995	7	MATERIALS PROCESSING CARGO BAY ACTIVITIES
3M	1996		MATERIALS PROCESSING FOLLOW-ON INVESTIGATIONS
3M	1996	7	MATERIALS PROCESSING CARGO BAY ACTIVITIES
CASE WESTERN	1996	1	COMPOSITE MATERIALS FOR LUNAR STRUCTURES ENVIRONMENTAL TEST
3M	1997	7	MATERIALS PROCESSING CARGO BAY ACTIVITIES
3M	1998	7	MATERIALS PROCESSING CARGO BAY ACTIVITIES
3M	1999	7	MATERIALS PROCESSING CARGO BAY ACTIVITIES

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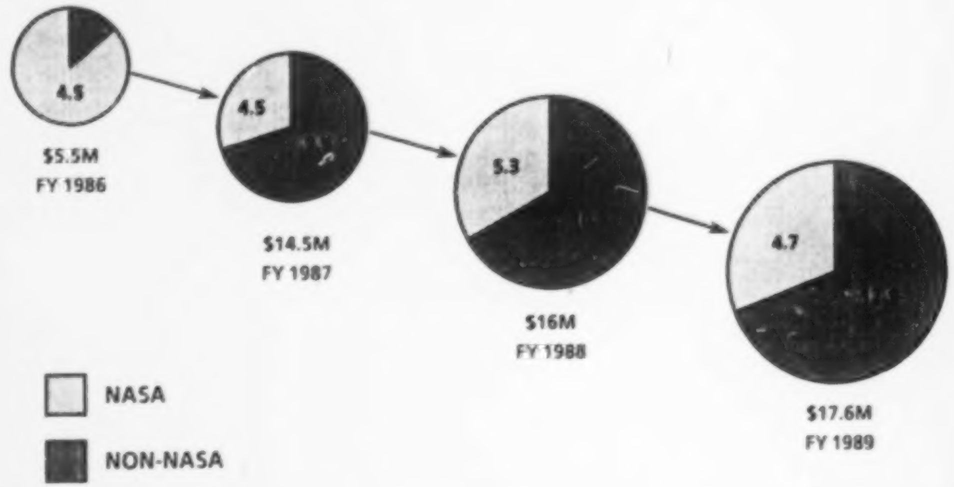
CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE

NASA/NON-NASA SUPPORT FOR FIRST 5 CCDS'S
(BATTELLE, UAB, UAH, ITD, VANDERBILT)



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NEAR-TERM COMMERCIAL DEVELOPMENT PAYLOADS TENTATIVE PLANNED/ACTUAL FLIGHT ACTIVITY

STS-26	SEP 88*	3M CORPORATION UNIVERSITY OF ALABAMA - BIRMINGHAM
STS-29	MAR 89*	UNIVERSITY OF ALABAMA - BIRMINGHAM
SOUNDING ROCKET / WHITE SANDS TEST FACILITY	MAR 89*	INSTRUMENTATION TECHNOLOGY ASSOCIATES, INC. HERCULES PHILLIPS PETROLEUM TELEDYNE BROWN TELEDYNE WAH CHANG MCDONNELL DOUGLAS UNIVERSITY OF CALIFORNIA - BERKELEY UNIVERSITY OF ALABAMA - HUNTSVILLE
STS-30	APR 89*	ROCKWELL INTERNATIONAL
STS-34	OCT 89*	3M CORPORATION
STS-32	NOV 89*	ROCKWELL INTERNATIONAL UNIVERSITY OF ALABAMA - BIRMINGHAM
SOUNDING ROCKET / WHITE SANDS TEST FACILITY	NOV 89	PENN STATE UNIVERSITY UNIVERSITY OF COLORADO BATTELLE UNIVERSITY OF ALABAMA - HUNTSVILLE
STS-31	DEC 89	UNIVERSITY OF ALABAMA - BIRMINGHAM BATTELLE - AMOCO

(BASED UPON FEBRUARY 1989 MANIFEST)

* ACTUAL OR ASSIGNED

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PRIVATIZATION/COMMERCIALIZATION ACTIVITIES

TYPE	KEY ISSUES	KEY ACTIONS
INFORMATION SYSTEMS • COMMUNICATIONS • REMOTE SENSING	• NASA/INDUSTRY TECHNOLOGY ADVANCEMENTS • LICENSING ON FOREIGN VEHICLES	• COMMUNICATION SATELLITE - CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE (CCDS) • SPONSOR MORE ACTIVE REMOTE SENSING PROGRAM
TRANSPORTATION	• INSURANCE • INTERNATIONAL COMPETITION • SOUNDING ROCKETS - LACK OF NONGOVERNMENT CUSTOMERS	• EXPENDABLE LAUNCH VEHICLE AGREEMENTS • SOUNDING ROCKET PROGRAM • IDENTIFICATION OF ADDITIONAL DEVELOPMENT OPPORTUNITIES
INFRASTRUCTURE	• IDENTIFYING OPPORTUNITIES • CONSISTENT POLICIES • PROCUREMENT POLICY WHICH FACILITATES CONTRACTS • DEVELOPING COMMERCIAL SPECIFICATIONS • NASA "CULTURE CHANGE"	• COMMERCIALIZATION POLICY AND CRITERIA • DEVELOPMENT OF FINANCIAL ANALYSIS CAPABILITY
NEW PRODUCTS AND SERVICES	• CONSISTENT, ASSURED FUTURE SPACE TRANSPORTATION • BROAD, FLEXIBLE PRICING POLICIES • INSURANCE • INTERNATIONAL COMPETITION • NEED BETTER MICROGRAVITY DATA BASE	• DEVELOP FLIGHT PLAN TO MEET REQUIREMENTS • PRICING STUDIES FROM USERS' PERSPECTIVE • MANAGEMENT STRUCTURE TO BRING CCDS'S INTO MAINSTREAM • STREAMLINE AGREEMENT PROCESS • MICROGRAVITY PROGRAM
FULL COMMERCIALIZATION	• DEFINING FULL COMMERCIALIZATION GOALS • PLANNING FOR REALIZATION OF GOALS • INTERNATIONAL COMPETITION	• STRATEGIC PLANNING • COMMERCIAL PROGRAMS ADVISORY COMMITTEE • NEW OPPORTUNITIES FOR SMALL BUSINESS

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03-27-89 --TEM

Mr. MINETA. Thank you very much, Mr. Rose.

Mr. Jelinek.

STATEMENT OF FRANK J. JELINEK, DIRECTOR, ADVANCED MATERIALS CENTER FOR COMMERCIAL DEVELOPMENT OF SPACE, BATTELLE COLUMBUS LABORATORIES

Mr. JELINEK. Thank you, Mr. Mineta and Mr. Perkins. It is indeed an honor for me to be here talking to you a little bit about what the CCDS's are and how they operate both from the standpoint of some of the problems that we are experiencing as well as some of the successes that we are experiencing.

Dr. Bugg and I have been, as Jim referenced, one of the original set of five centers that were awarded back in late 1985. So we have had the opportunity up to this point in time to be in business, so to speak, for three and a half years or thereabouts.

As a result of that, we have gained a lot of insights and experience that some of the younger centers are just now living through, and hopefully we can help them with that.

Dr. Bugg and I both propose in this short testimony that we are going to give you to presume to speak for the other 14 CCDSs that are not here. We are a very close knit group and we are attacking this problem in very much the same way with each other, and we are approaching our problems and our concerns in a unified fashion.

[Slide.]

I'm going to expand a little bit more on what the definition of the CCDS mission is in our judgment, and the next slide will show a little schematic that I think very clearly describes it at least to us.

The CCDS, we see ourselves as a sort of a middleman, an interface between the private sector of the United States and NASA and the powerful technology for space transportation and other things that NASA has developed.

Our purpose to exist, our very real reason to exist is to try to bring along as many private sector companies as we can to first of all alert them to the possibilities of unique aspects of space, secondly to educate them in terms of what can happen and what they might be able to do within their own product line and within their own technology area and, thirdly and finally for us is to get them involved.

Once they get involved, we see the industry companies entering into different kinds of interfaces, probably most directly with NASA themselves. Much of what industry does in terms of new product development, for example, is proprietary, at least for a time, and patent positions are important things that industry people do and try to establish. They can probably best establish those kinds of benefits for themselves by working directly with NASA and saving the middleman.

So what you see on that curve over here is that what we as a CCDS are trying to do is bring them in at the curiosity level and have them interact with some of our university scientists and engineers, and have them discuss, hey, we make zeolite catalysts and what would be the advantage of microgravity, together to attack that problem and come up with some sound scientific reasons why it might be helpful.

Next you move to another phase. You might end up doing some suborbital testing like drop tubes or drop towers, sounding rockets, KC-135 aircraft and so on. All along this curve we, the CCDSs are essentially taking these private sector companies up that learning curve. We get to a point sooner or later where somebody is going to say, ah ha, we have found a niche in this marketplace and we want to use it.

We currently have such a company associated with us who are at the stage of commitment at this point in time. But that's our goal. We want to bring those companies to that stage of commitment. The dotted lines you see on that little chart up there means that we are not going to be successful totally.

We have eight member companies in our center at Battelle at this moment. We have had as many as nine and we have as few as six, but the cast of characters are different. Some of them went to Phase A, B or C along that line and decided no, at this time at least it's not for us. Maybe they couldn't get any corporate money to spring loose to help us either, I don't know. But the point is for them this time was not right.

So another function of the CCDS which is critically important, and one of my major jobs as Director of one of these 16 CCDSs is to go out and beat the bushes and talk to non-aerospace companies who want to be a part of this program and who want to learn at a relatively early small investment what can be done. So you see in the two axis on the side we have degree of interest going up and we have the dollars going up all as a function of time.

Now obviously as you get to a committed stage, like one of our companies is, and I'm not afraid to identify it and I will on a later slide, the cost gets higher, and their stake in this whole business gets higher.

[Slide.]

The second element that I want to talk about briefly, and there are only four, and I am already done with one, the second element that I want to talk about briefly is the interaction of government, academia and the private sector.

When you first think about that, it sounds like it could be a potential nightmare, and it is in some ways, but there are ways to get around that. Universities, for example, have the general philosophy of publishing and going out into the public world with everything that they do. So it's not very convenient for them to have one of our industry partners involved in the CCDS to tell them we'll be happy to help fund with NASA grant money and also with some of our own money this experiment. However, you can't publish the data. We want you to hold it for 18 months or we want to hold it for 12 months. And the reason we want you to hold it is we want to evaluate it more seriously ourselves to find out and determine how sensitive it really is, and then we'll find a way for you to publish it.

Universities have to make certain concessions therefore to be involved in our programs, and they have done so very well. They have done so with a tremendous amount of cooperation. Oftentimes, however, it does take a trip to the provost or the university president himself to get a contractual exception, a subcontracting exception to their normal policy.

By the same token, the industry partners don't necessarily want to share with a university professor or a couple of graduate students a few little tricks that might help them achieve their goal much quicker because within their own company's research structure those things may be bordering on proprietary as well.

So it's the responsibility of the CCDSs to bring these people together in a roundtable kind of way and hammer out solutions that are going to be acceptable to both sides, and I think we have been very successful in doing that up to this point in time.

[Slide.]

The next slide is for our center alone, and it's sort of like the slide that Jim Rose showed a moment ago in terms of the industry's commitment in how it's growing as a function of time in the program.

This is different than Jim's slide in the fact that here I am talking about cash contributions by industry. If we added to these bars in-kind contributions, the bars would approximately double in each year that is list there. But as you can see, estimated in 1989, which is the current fiscal year, we are anticipating our industry partners contributing $700,000 cash to the program.

Since our grant is $850,000 from NASA Code C, our industry involvement already is nearly on a cash basis nearly half, nearly 50/50. When you add to that the in-kind services that each of our industry partners commits to the program, and by in-kind services we mean utilization of their facilities, utilization of their staff, utilization of their high-tech equipment. For example, we are using a supercomputer for nothing. We have already in the last quarter alone have put 30 hours on a supercomputer. That is not cheap, but we are getting it free. Those are things that we talk about as in-kind services. That adds up to substantially a lot more money.

So we are talking a leveraged amount of money for any given industry partner. He is getting a pretty good deal, the universities are getting a pretty good deal, our young people are getting educated in space science and technology and all in all the CCDS is accomplishing its mission.

[Slide.]

Quickly just a brief comment on this. Approximately 60 percent of our available dollars, exclusive of in-kind services, is subcontracted to universities. We formed an advisory group as well. This is composed of industry and university members alike, and they sit in regularly scheduled meetings and discuss problems of intellectual property and how to handle reports of invention. So far in the Battelle Center we have 10 reports of invention in the time that we have been in existence, and we have three of those that patents have been applied for and one in which the patent has been awarded so far.

We also have master agreements set up with these universities and these run for periods of five years. And thereby by having such a master agreement the university administration knows in advance for the next five years what their people are getting involved in and what the uniqueness of our program is. So they can approve it in advance and it seems to be working very well.

[Slide.]

Just some brief comments, particularly on the last third of this overhead. There is a mistake in the first third. Instead of "cost" that should say "cash," and in some of the viewgraph handouts that are on the table outside it says "cast." In any case, we are talking about money there.

One of the things the industry does is it supplies the total commercial focus of this program. That's not to say that universities cannot come up with good ideas and good science. They do that very well. But it has to be understood that most of our private sector companies that are involved with us have excellent science themselves going on within their institutions, plus they have a product line, plus they have a bottom line in terms of profitability. So they call the shots. There is really no question and we make that very clear right at the outset, that you, Amoco Chemical Company, or you DuPont, or you Hercules, you're going to guide this research program and tell us where you want to go.

So we do not work in things where we don't have industrial support one-on-one at least, and sometimes it's more than one-on-one, sometimes we'll have two or three industries involved in the same general technology. But we won't arbitrarily go to another technology and work unless there is someone who can definitely commit and align themselves from the private sector with that technology. Hence, the scopes of some of our centers are different.

Charlie right now is working with a certain group of pharmaceutical companies who have specific interests. As soon as Dr. Bugg gets different pharmaceutical companies with different interests, he will do those.

[Slide.]

These are our members, I have listed them for you, and I'm not going to go through the trouble of reading them. They are in the written testimony.

[Slide.]

The next slide is a list of our university affiliates. We have seven, which we are very proud of. We have chosen them by invitation to become a part of our center because they have microgravity science and space technology experience.

[Slide.]

The technology thrust that our particular center is involved in is in catalysts, which is a very big one and strongly impacts the gross national product of this United States, all kinds of catalysts, polymers is the second area, and electronic materials, specifically the float zone crystal growth of cadmium tellurite, a very, very high value added material for sensors and detector devices and, finally, ceramics and ceramic superconductors, which we are working on with the same kind of hardware development activity that we are using for the semiconductor development.

[Slide.]

Our flight opportunities so far are those listed there. We are manifested on STS-31, which is coming up in December or November, I forget, of 1989. We are in the process of getting through safety review at Johnson Space Center at this time.

We are on the next sounding rocket experiment, which is called Consort II, where Battelle has about one-third of the payload space, and we are going to fly three polymer experiments on that.

We are meeting in Huntsville, Alabama on Thursday of this week to clear the way for two experiments in hydrothermal crystal growth of zeolites to go onto USML-1 which is scheduled in March of 1992. Again, there are a couple of errors on your written handout which are corrected on this overhead, but my secretary didn't know those flight numbers. So they are not in there.

[Slide.]

Finally, the fourth and final item of my brief comments is that we are not without concerns, and I probably didn't even list them all and Dr. Bugg may have a few more. The other thing about concerns is that they come and go. It used to be that one of our top concerns that we would list on a chart like this in talking to any group was how to handle intellectual property, how to deal with inventions and patents and how to deal with licensing the technology to other people.

Well, we have been working hard on those in the last couple of years and we have a lot of those answers. I'm not prepared to tell you all about the answers to those questions today, but we have worked hard with both NASA's legal counsel and with industry legal counsel and with legal people that we have attached to our various respective centers. We are making good progress with that. So I don't even list it any more because I think it's workable.

But flight opportunities is a problem. We judge at this point in time, although we are encouraged recently, that we don't have anywhere near enough flight opportunities that we can see coming down the pike that would satisfy what we all would like to do. So I listed up there several things, regardless of their status in today's thinking. There are several possibilities.

Basically the CCDS is saying to NASA we'll fly on anything you can give us. So give us a chance. If you're only going to guarantee 10 to the minus 3 G, that will be okay for this experiment. If you are going to give us 10 to the minus 6 free flyer, we'll use for this experiment. Basically what we are saying is we will take whatever we can get and we'll be glad to have it, anywhere from 2 seconds to 5 days or 10 days or 12 days or whatever it can be, or ultimately a Space Station itself. So that's a concern we have.

The second one that is listed there is cost effective hardware development. With all due respect to the giant aerospace companies who have major U.S. contracts for elements of this Space Station, crew safety, recovery from the Shuttle and any number of major, major projects, and the structure within the organization to go along with those projects. A lot of the projects in hardware development activities that we are encountering are much smaller in scale than those are, commercially significant, yes, but smaller in scale. We're talking $300,000 or $400,000 or $500,000 to build a piece of equipment.

If we contract that with one of the larger aerospace companies we have to get in the queue for one thing. So it's going to take a long time. It has a tendency to get overworked, and it has a tendency to probably not be as easily accessible by the key engineering team that is going to actually be responsible for the experiment.

So what we would like to see at least with regard to our hardware construction is to involve smaller businesses, people that are real craftsmen, real good in their trade, involve them and bring them into the program and have them working intimately, and because of even those kinds of dollars that I mentioned, $3 to $500,000, that's a good business deal for them. That becomes profitable for them and they can afford to dedicate people to us for that.

Now when it comes to integration of space flight, we need aerospace companies oftentimes to help us with that. NASA provides us all of their staff at all the field centers for this purpose, but some of the aerospace companies are very well versed in this if they have jumped through all these hoops before, and so in that context we still want them and need them as well. I'm talking mostly here about construction of relatively simple basic hardware that is space qualified.

Finally, or two more things, we need a little bit better PR with the private sector, and by that I mean I would be good to have the NASA Administrator call the CEO of Amoco Chemical Company and tell him how good it was to see him participate in a very significant national endeavor. And I think at all levels of industrial management and government management this could be done more effectively, and we as a CCDS would be happy to set up the appointments.

Finally, technology transfer strategy. Currently the CCDSs are operating under a domestic only situation, and by that we mean that the only companies that can become members of a specific CCDS must be at least 51 percent U.S. owned. Now that eliminates a lot of very potential high-tech organizations that would contribute significantly to commercial processes in space. But, nevertheless, I am not here to defend or tear down that particular philosophy. I think that domestic only is good in many, many cases, and we certainly know how well it can be controlled and needs to be controlled within DOD and other places.

The thing is that there is some good work going on in Europe and Japan, and they are hearing about our CCDSs, they are hearing about Charlie Bugg's protein crystal growth stuff and they are starting to duplicate that activity. They may not have all the information they need, but they have mighty powerful pharmaceutical firms in Europe, and I think it might be important under certain well controlled situations if the CCDS movement or the industrial sector in the United States could interact a little bit more fully with those foreign entities because we may be able to learn something.

It's probably not so much for us to worry how much we are giving away, and we might be able to come out net ahead if we could learn a little bit more from them because some of them are doing some excellent work.

That concludes my remarks to the Committee. Thank you very much.

[The prepared statement of Mr. Jelinek follows:]

STATEMENT OF

FRANK J. JELINEK
DIRECTOR

THE ADVANCED MATERIALS CENTER FOR
THE COMMERCIAL DEVELOPMENT OF SPACE

BATTELLE
Columbus, Ohio 43201

before the

Subcommittee on Space Science and Applications
Committee on Science, Space, and Technology
U.S. House of Representatives

April 11, 1989

Mister Chairman and Distinguished Members of the Subcommittee:

Mr. Rose, NASA Assistant Administrator for Commercial Programs, has stated that a major thrust of the Office of Commercial Programs (OCP) is the establishment and support of the Centers for the Commercial Development of Space (CCDS). As the Director of one such Center established in late 1985, I am pleased to have this opportunity to brief you on the CCDS concept, including the successes and difficulties we have experienced to date. Dr. Bugg and I presume to be able to speak adequately for the entire group of 16 Centers, inasmuch as we are a close-knit interacting group who share common goals and approach concerns and problems in a cooperative manner. My remarks will focus on the following items:

- Definition of the CCDS Mission
- Interaction of Government, Academia, and the Private Sector
- Progress within Battelle's Advanced Materials Center
- Issues and Concerns shared by the CCDS's.

Definition of the CCDS Mission

The CCDS mission has evolved very clearly to those of us who are intimately involved in the program. Put simply, it is to alert, educate, and involve the private sector of the United States in the advantages of space science and technology. Once involved, it is our expectation that the private sector companies will identify specific market opportunities for themselves, utilizing the unique environment of space. These could include new products and processes, innovative engineering technologies, such as space power systems and robotics, and medical advances (e.g., improved macromolecular network understanding leading to improved earth-based drug design and engineering--Dr. Bugg will speak to this).

It is important to point out, at this juncture, that the commercial development of space is **not** synonymous with "manufacturing in space". It is true that certain high-value-added products (e.g., certain electronic crystals or biological materials) will be manufactured in orbit, on the moon, or other non-terrestrial body; but the value of U.S. Industry involving themselves in space science and technology is much broader than that. To those industries involved in materials development and in the manufacture of devices requiring highly perfect and pure materials, the parameter of gravity is both a gift and a curse. Gravity is a gift to all of us, if we want to remain here, and, of course, we are all happy that water flows downhill. However, to a materials scientist and engineer, gravity causes a number of problems. He would like to forego the use of a container to melt an alloy--because the container walls add impurities to his system; he would like to have his catalyst crystals remain in the nutrient-rich area of the solution and not settle to the bottom; and he would want his two-phased polymer system, each phase of different density, to remain uniformally distributed and not separated. In our personal lives, we compensate for this gravity effect--we shake our container of orange juice in the morning before pouring a glass. American industry and American scientists and engineers at large are smart enough to deal with these problems if they know fully what the effect of taking the gravity parameter away will do. This program provides them the opportunity to do that. For most of our industrial partners, this is as important as space manufacturing.

Now, getting directly back to the mission of the CCDS's, we see ourselves as middlemen, bridging the gap between the highly sophisticated NASA-developed space technology and the forward looking non-aerospace companies who want to align themselves with 21st century technology. Our collective experience has shown that the Industry Partners come into the program with a mix of agendas. Some are motivated by curiosity, believing, as a minimum that they cannot afford to be uninformed. Others come in with a spirit of competition, i.e., if oil company A is involved, we (B) better stay on top of what is going on. Still others have given the advantages of space a lot of thought. They want to pursue something specific. They are not ready to make a major financial commitment, but they see the CCDS program as an incentive to add to their data-base, to clarify their thinking, and to participate in a worthwhile national endeavor. The CCDS can serve all of these industry interests. Obviously, assistance with flight opportunities and the availability of these opportunities is a key to the success of the CCDS, i.e., having industry prove to themselves, based on early results, that space science and technology is a line-item in their strategic plan.

Finally, the CCDS program should be looked upon as a constantly renewing, nurturing ground. As companies mature toward commitment to space science and technology in a specific technology area, the need for their involvement in the CCDS, in that area, will diminish and ultimately disappear. This is as it should be. The company can then begin to conduct its own business directly within the OCP and the Space Transportation System (STS) of NASA. That same company could have new technology areas it would like to pursue under the CCDS program. Here again, the CCDS could assist and provide the "middleman" approach of microgravity justification, technical feasibility, etc.

While all this is going on, the CCDS continues to bring the program to new companies. The cycle is constantly repeated in terms of bringing the private sector up the "learning curve" from curiosity to commitment. All of the CCDS's recognize and accept the reality that government budgetary support for this activity will not last forever. It is incumbent on each of us to develop ways to be self-sustaining. This is quite possible, especially after a "few" on-orbit successes. Operational income for a CCDS can be realized from the private sector from many possible sources. These include:

- Royalty share on developed intellectual property
- A percentage of the sale of intellectual property to third parties
- Licensing agreements with the Center by and through its members
- Endowments of Appreciation (an invented term for the purpose of this presentation) by mature industries who have gone on their own in certain technology areas
- Sale and lease of space-qualified hardware that has been developed
- Spin-off and vested interest in businesses created by the private sector.

All of these options, and more, are possible in the next several years. I do not claim to understand or have the answers to how these various options can or will come about. There are, undoubtedly, legal and proprietary issues to be resolved. I am confident, however, that well intentioned people within the Congress of the United States, NASA, the CCDS's, and the Private Sector will work together to provide guidelines within NASA policy and the Laws of the United States.

The CCDS program within the NASA Office of Commercial Programs is a significant and worthwhile attempt to involve the economy of our country and our people in a new venture of commercial significance.

Interaction of Government, Academia, and the Private Sector

Having described the philosophy and mission of the CCDS program, it is, hopefully, clear that many participants must cooperate rather extensively in order to attain success. There are several groups of participants involved in this program. It is fair to say, in many cases, standard or "traditional" approaches to solving a problem or to carrying out business had to be abandoned. Considering all the participants, in turn, some brief comments are in order.

Government. NASA Code C budget provides an average of $1M to each of the 16 CCDS's annually. This appropriation is in the form of a grant. Renewal proposals are required each year and normal grant rules apply. The program is administered out of Code C within NASA Headquarters. However, virtually all of the NASA Field Centers are involved in technical guidance, flight integration, and overall support. A condition of the grant award, and it continuance, is that the private sector must provide a substantial and auditable contribution to the overall program in the form of cash or in-kind services. Since late 1985 (the awarding of the first CCDS's), this contribution by industry has increased steadily. The members of the various CCDS's outline their own technology thrust and, in this, NASA does not interfere. Strict adherence to NASA regulations, however, is required regarding preparation for manned or unmanned space flight. Most CCDS's have already established excellent relationships with Marshall Space Flight Center (MSFC) for flight integration, Johnson Space Center (JSC) for safety, Kennedy Space Center (KSC) for final integration, and the others for various forms of technical guidance and suborbital and ground-based assistance.

NASA's legal office works with all of the CCDS's constantly regarding intellectual property rights, non-disclosure of data, proper accounting procedures, and the overall protection of private sector interests. The CCDS management team is the focal point of this activity and works closely with the Industry Partners and University Affiliates to implement the requirements of the program.

Academia. The use of University Affiliates is critical to the success of the CCDS. First of all, many of the University professors and associate professors (and their graduate students) chosen for work in the CCDS, have vast expertise in space or microgravity science. They have the fundamental perspective. They can take the commercial problem, reduce it to basics, and ascertain whether microgravity will be of value. While the CCDS's have a commercial thrust, the University input is invaluable in pointing out the scientific pitfalls and some of the solutions. In addition, the involvement of Universities contributes directly to the education of our young people, graduates and undergraduates alike--a legacy of the future--in space science and technology. Currently, there are 48 Universities involved in the CCDS programs. At the Battelle Center, we have carefully chosen seven (7) universities to be involved with us.

The involvement of universities is not without its headaches. With all due respect, the university philosophy is one of being free to publish, indeed encouraged to publish. With commercial entities involved in the program, this freedom of publication approach has not been encouraged--indeed discouraged. To circumvent this problem, we at the Advanced Materials Center have installed two steps (other Center's have as well). The first is the establishment of an Industrial Advisory Group. This group, along with the university author, will evaluate the proposed publication and, by mutual agreement, will delete "sensitive" material. This procedure has resulted in the protection of proprietary data and, at the same time, permitted the publication of sound scientific papers and/or dissertations. The second step is to enter into a

5-year Master Agreement with our selected Universities. By so doing, University Administrators can approve, in advance, the unique nature of our program.

We have found our universities to be extremely cooperative and excited about this venture. The Center enters into a sub-contract relationship with them--paid for partially by industry and NASA grant funds. The Universities normally discount 20 to 30 percent of their overhead burden in their cost proposals to aid in the support of the Center.

Private Sector. As previously described, the private sector is the very reason this program is in existence. It is important for the CCDS to cater to the commercial activities the private sector wants to perform or learn about in space, provided the potential exists on a sound scientific basis. The private sector wants to fly ASAP because of the drive for a short-term as well as a long-term payoff, which is another tradition in another sector of our U.S. economy. There are currently 130 or so major U.S. companies involved in the CCDS program. Granted, they come with varying degrees of interest, but, at this moment, they are listening and responding. Their cooperation with the mix of participants described earlier has been extraordinary. I sense a willingness, within the private sector, for a shared understanding of the advantages of space, even with their competitors. Their own application of new discoveries will remain theirs.

As you can see, with this mix of participants, the CCDS's try to facilitate the future thrust into space by the U.S. economy. It is not an easy task, but it is bearing fruit.

Progress Within Battelle's Advanced Materials Center

I just want to spend a few minutes telling you about what we are doing at the Advanced Materials Center. Our Center for Advanced Materials has four (4) main technology thrusts:

- Catalysts
  - Zeolites
  - Mixed Oxides
  - Mixed Halides
- Polymers
- Electronic materials
  - CdTe
- Superconductivity.

The areas in which we are working all have strong industrial support. The most significant areas and the ones most ready for space flight are the Zeolite catalysts, the Polymers (specifically polymer membranes), and the CdTe electronic materials. We are happy to report that the polymer membrane study is scheduled for STS-31 in December 1989, as well as three (3) experiments on the Consort II sounding rocket in October of 1989. The Zeolite catalyst experiments (2) are manifested on USML-1 in March 1992 and we expect to fly precursors in 1990. We are negotiating with Gruman Aerospace to use their furnace for a CdTe crystal growth experiment in 1993. In the meantime, we expect to re-fly both polymer experiments in 1990.

The following Industry Partners are affiliated with the Battelle Center for Advanced Materials:

Amoco Chemical Company
DuPont
Hercules
Master Builders, Inc.
PPG
Rockwell International
Teledyne-Brown Engineering
II-VI, Inc.

The following Universities are affiliated with the Battelle Center for Advanced Materials:

Akron University
Case Western Reserve University
Clarkson University
Cleveland State University
Ohio State University
Washington State University
Worcester Polytechnic Institute.

Issues and Concerns Shared by the CCDS's

In our judgment, the CCDS program is proceeding on schedule and with positive results. On the order of 60 flight experiments have been requested by the 16 CCDS's--most with full industrial support. Dr. Bugg's early success with protein crystal-growth is a wonderful precursor to other technologies that will emerge in space science and technology.

The issues and concerns that we have, therefore, can be wrapped up in a few bullet items:

- We need flight times. There are many good, well-developed experiments, that can be ready (recent opportunities have been encouraging).

- Hardware development for experiments projected by the CCDS's is beyond our budgets, when "traditional" aerospace companies are utilized. With all due respect to these giants of the industry, we need to qualify smaller business craftsmen to work with us and NASA. This action would be cost effective and safe.

- Industry involvement in the space program needs to be encouraged and pro-actively supported by NASA Administration and Congress.

- Our allies, mostly Japan and Europe, are keenly interested in what we are doing in the CCDS program. Some foreign programs are duplicating our efforts, based on information received through normal press releases. Some foreign programs are quite impressive. Under certain, well-defined circumstances, it might be useful to cooperate with our foreign friends. Our domestic-only policy currently precludes this possibility.

It has been my pleasure to present these views to you today. I am confident that our space program will be extremely productive for all America.

Thank you.

Frank J. Jelinek
Battelle
Columbus Division
(614) 424-6376

FJJ:aa

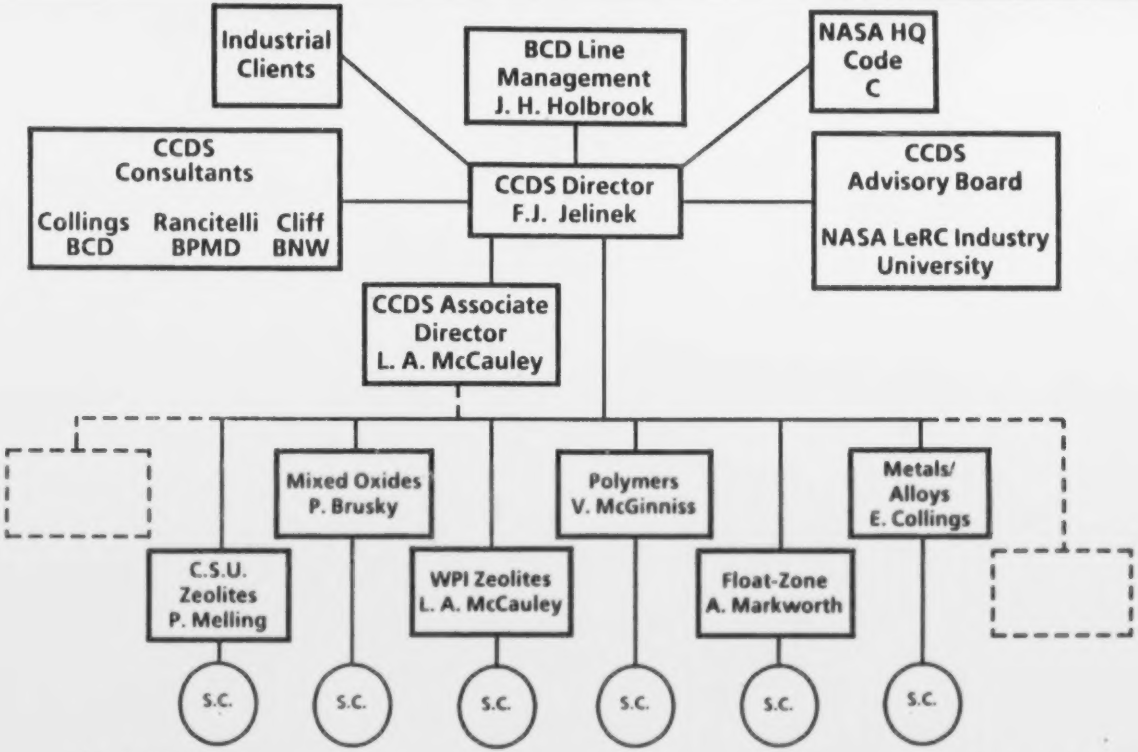
Advanced Materials Center for the Commercial Development of Space

Battelle

Frank J. Jelinek, Director

Advanced Materials Center for the Commercial Development of Space

Battelle
... Putting Technology To Work



Industrial Clients

BCD Line Management
J. H. Holbrook

NASA HQ Code C

CCDS Consultants
Collings BCD
Rancitelli BPMD
Cliff BNW

CCDS Director
F.J. Jelinek

CCDS Advisory Board
NASA LeRC Industry University

CCDS Associate Director
L. A. McCauley

C.S.U. Zeolites
P. Melling

Mixed Oxides
P. Brusky

WPI Zeolites
L. A. McCauley

Polymers
V. McGinniss

Float-Zone
A. Markworth

Metals/ Alloys
E. Collings

S.C. = Subcontracts

TESTIMONY AGENDA

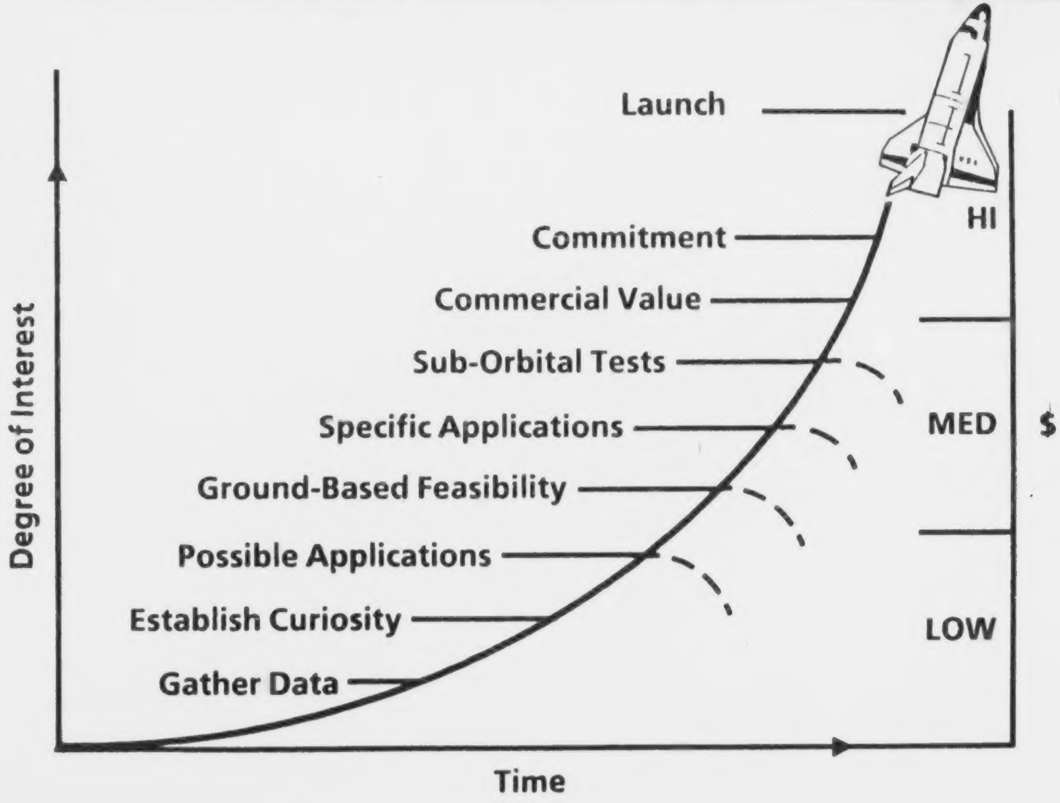
Battelle
. . . Putting Technology To Work

- Definition of CCDS Mission
- Interaction of Government, Academia, and the Private Sector
- Progress within Battelle's Advanced Materials Center
- Issues and Concerns

DEFINITION OF CCDS MISSION

Mission: Private Sector's Journey into Space

Battelle


Launch
Commitment
Commercial Value
Sub-Orbital Tests
Specific Applications
Ground-Based Feasibility
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Establish Curiosity
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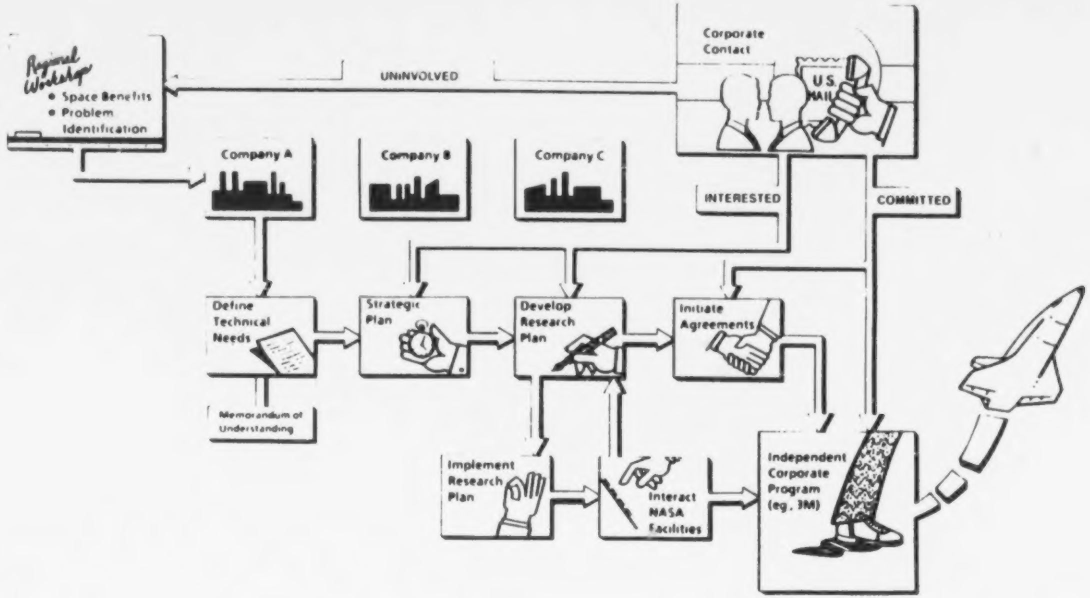
Strategy for Industry Involvement in Commercial Space

Battelle


Regional Workshop
• Space Benefits
• Problem Identification
UNINVOLVED
Corporate Contact
U.S. MAIL
Company A
Company B
Company C
INTERESTED
COMMITTED
Define Technical Needs
Memorandum of Understanding
Strategic Plan
Develop Research Plan
Initiate Agreements
Implement Research Plan
Interact NASA Facilities
Independent Corporate Program (eg. 3M)

BECOMING A SELF-SUPPORTING CENTER

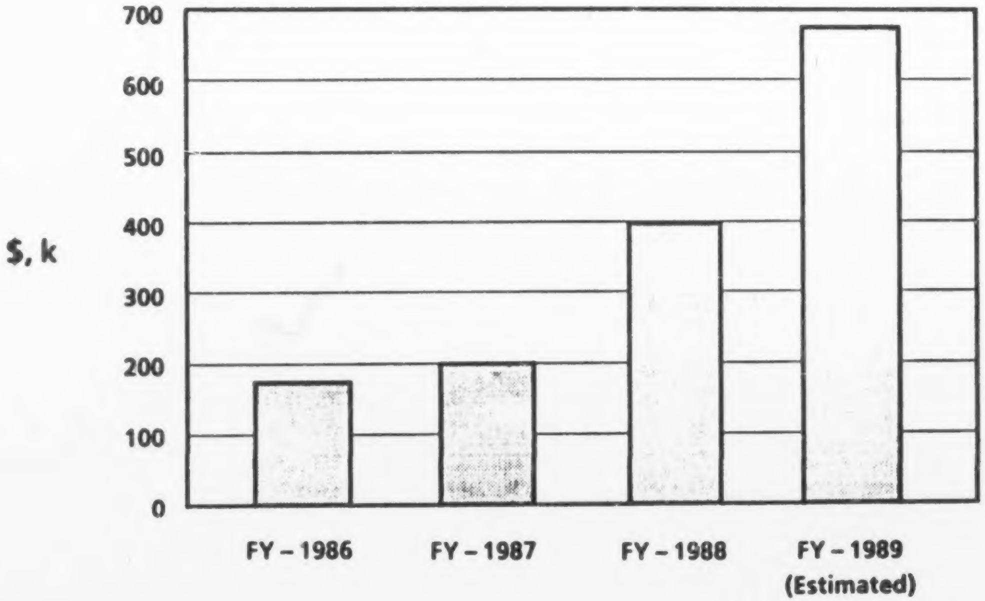
Battelle
. . . Putting Technology To Work

- New Members and Appropriate Fees
- Royalty Share on Developed I.P.
- Sale of I.P. to Third Parties
- Licensing Agreements
- Endowments
- Sale and Lease of Hardware
- Spin-off Companies

INTERACTION OF GOVERNMENT, ACADEMIA,
AND THE PRIVATE SECTOR

Industrial Support

Battelle



UNIVERSITY INVOLVEMENT

Battelle
. . . Putting Technology To Work

- Approximately 60% of Budget is Subcontracted to Universities (allows for possible State matching funds)
- Advisory Group Established to Insure Industry-driven Focus
- Master Agreements Arranged with Universities

PRIVATE SECTOR

Battelle
. . . Putting Technology To Work

- Supplies Commercial Focus
- Advises Program
- Supports Program (cast + in-kind + technology transfer)

- Establishes Commercial Thrust for their Interests
- Enters into JEA or Other One-on-One with NASA
- Becomes NASA Customer (flight service, lunar-base, exploration, etc.)

- Ultimately Impacts the U.S. Economy with:
    - jobs, job training
    - education
    - new products, cures
    - high technology (commercial)
    - world leadership

Battelle
. . . Putting Technology To Work

PROGRESS WITHIN BATTELLE'S
ADVANCED MATERIALS CENTER

INDUSTRIAL PARTNERS

Battelle
. . . Putting Technology To Work

- Amoco Chemical Company
- DuPont
- Hercules
- Master Builders, Inc.
- PPG, Inc.
- Rockwell International
- II-VI, Incorporated
- Teledyne Brown

Center Affiliates

Battelle

Government – NASA Lewis Research Center
Other NASA Centers
State of Ohio

Universities – Akron University/Edison Polymer Institute
Case Western Reserve University
Clarkson College
Cleveland State University
Ohio State University
Purdue University
Washington State University
Wooster Polytechnic Institute

Technology Thrusts

Battelle

- Catalysts
  - Zeolites
  - Mixed Oxides
  - Mixed Halides
- Polymers
- Semiconductor Crystal Growth
- Ceramics, Superconductors

FLIGHT OPPORTUNITIES

Battelle
. . . Putting Technology To Work

Consort II	-	November 1989	3 polymer experiments
STS-3	-	December 1989	polymer membranes
STS (USML-1)	-	March 1991	zeolite catalysts (2)
--	-	1993	CdTe float zone crystal growth

Two precursors to USML-1 on zeolites in 1990 (middeck)

GAS can on Zeolites in July 1990

Refly of 1989 experiments on polymers in 1990

ISSUES AND CONCERNS

Battelle
. . . Putting Technology To Work

- Flight Opportunities
  - shuttle
  - ELV's
  - CDSF, Spacelab, etc.
  - space station
  - sounding rockets
- Cost-Effective Hardware Development
- Good Private Sector PR for the Space Program
- Technology Transfer Strategy:

Foreign $\rightleftarrows$ Domestic, Who Wins?

ISSUES AND CONCERNS

Battelle
Putting Technology To Work

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- Good Private Sector PR for the Space Program
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  Foreign $\rightleftarrows$ Domestic, Who Wins?

Mr. **Mineta**. Thank you very much, Mr. Jelinek.

Dr. Bugg.

STATEMENT OF DR. CHARLES BUGG, DIRECTOR, CONSORTIUM FOR MATERIALS DEVELOPMENT IN SPACE, UNIVERSITY OF ALABAMA-HUNTSVILLE

Dr. **Bugg**. Mr. Mineta and Mr. Perkins, it's a real honor and pleasure to be able to meet with you.

I want to second everything that Frank Jelinek has said in general about the CCDSs. Essentially everything he has covered would also apply to the one in Birmingham, plus the other 14 that are not represented here.

So what I would like to do is go into a little more detail about our CCDS in Birmingham which is in the unusual position of having been able to fly a number of times and having companies that are actually up in space, and rather than repeat anything Frank has covered, I will try and give you some perspective in a little bit more focused manner relative to the CCDS in Birmingham.

[Slide.]

The center in Birmingham was one of the first five that was established and in a manner that is maybe a little bit different from the other CCDS's. It's extremely highly focused, and focused in an area that is maybe not normally familiar to the public as a whole, although I hope the public is going to become more and more attuned to what is going on in this area. It's a field called protein crystallography dealing with the crystallography of biological macromolecules.

Our center is an intimate part of the Medical School at the University of Alabama in Birmingham. As Director I report directly to the Senior Vice President of the Medical Center, and it's very closely allied with our comprehensive Cancer Center, which is one of the major cancer centers in the United States and has a very strong biomedical bent to it.

[Slide.]

Protein crystallography is a technique for determining the architecture of biological molecules. At the present time it is the only method that allows ones to examine in great detail the three-dimensional architecture, the arrangement of atoms in very large biological molecules, and consequently it has been of a great deal of interest in the basic biomedical sciences and has considerable commercial potential.

[Slide.]

This summarizes what you can do with this information. The way this has been used primarily for the past two decades is for very fundamental studies of biological structure. Most of what we know about the way that genes operate, the way that enzymes work, the way the immune system works, most of the processes at the molecular level, the understanding has come about by these sort of basic studies.

And industry has the same level of interest. In order to design new classes of pharmaceuticals, it's oftentimes essential to know the way that the systems are operating at the molecular level so that you know how to intervene in the process. So just for basic understanding of biological systems most of our industrial affiliates have programs in crystallography that are geared in that direction.

From a more applied standpoint, if we know the structure of an enzyme or other protein that is a target for the design of a pharmaceutical agent. For instance, if you have an enzyme, such as reverse transcriptace, that the AIDS virus needs in order to replicate, and you know the structure of that target, you can then fairly quickly design drugs that are specifically tailored to fit that target. Without that structural information, the alternate, which the pharmaceutical industry has had to follow in the past, it's just to make and test tens of thousands of compounds hoping you happen to stumble across one that fits the target. So from the drug design standpoint, many of companies have strong programs in that area.

Another application that is going to have I think immense economic potential not only in the pharmaceutical industry but in the chemical industries is the field of protein engineering. It's not possible through techniques of molecular biology to go in the lab and make entirely new proteins using molecular biology techniques when you realize that enzymes, which are catalysts to proteins, the possibility of tailoring catalysts to carry out specific chemical reaction is very close to be an economic reality.

For the drug design and the protein engineering knowing structure is extremely useful, and right now the only way you can do that is by protein crystallography.

Now the bottleneck in all of this is the crystal growth stage. In order any of this, we have to be able to obtain high quality and highly ordered crystals, and that's extremely difficult on the ground. Most of the projects that are of real economic potential oftentimes never move beyond the crystal growth stage because of the fact that we can't get crystals that are suitable, highly enough ordered in order to do the things that you would like to do from the commercial standpoint.

[Slide.]

This shows the companies that are involved with our CCDS and this includes some of the major actors in the pharmaceutical and chemical industries. All of these companies have programs in protein crystallography using crystallography to try to develop new pharmaceuticals or develop other applications of this overall technology.

Among this list are companies that have never before been involved with NASA or with the space program, and it's unlikely that without some intermediate mechanism, such as provided by the CCDS, that these companies would be able to move at the rate that they are moving right now in the space program.

But these companies are all involved very actively in the CCDS program at a variety of levels, and they have the common interest that they are interested in accessing space to do protein crystal growth projects. These companies are working on a huge range of drug development programs ranging from AIDS through cancer through cardiovascular disease, arthritis, multiple sclerosis, juvenile diabetes, emphysema, growth defects, and in all of these things the targets are well known. But what they don't have is the structural information about those targets that will them move aggressively to the development of pharmaceutical agents to take advantage of those processes.

Of course, the health aspects of this are immense and economic aspects are immense. All of these pharmaceuticals that I'm mentioning, the sales would be in the area of hundreds of millions of dollars a year. The company that gets there first with the patent coverage is the one that is going to have most of that market. So the urgency to move very rapidly in these research programs is on a level in the pharmaceutical biotechnology industries that certainly parallels what you would see in a place like silicon valley. They are just after different areas of technology. In their case they oftentimes are restricted up front by their inability to grow crystals of high enough quality, which is the reason why they are so eager to be involved in what is going on with the Shuttle program.

[Slide.]

One thing that is happening in Birmingham that I think we are going to see happening more and more about the CCDSs is the formation of an entirely new industry locally that was stimulated by our CCDS. A group of local business leaders right after the center was formed saw the potential of having this sort of in-house expertise in Birmingham, and through local fundraising and local capital offerings a little over $5 million was raised and a company was formed called Biocryst that was formed to take advantage of the unique resources available in that CCDS.

Biocryst is now doing very well. They have their first patent on a class of drugs that, if it all works right, will end up in the clinic in the next year or so treating AIDS patients, and the economic potential for the Birmingham area is I think going to be immense. This was all done through local funds that were raised by local business leaders to take advantage of what the CCDS had to offer from a technology standpoint.

It's located in an incubation facility operated by the university and is typical of what a number of the universities are doing in trying to spin off technology, and it's one of the companies that is a member of our center and is involved in flying space experiments.

[Slide.]

Our center has been in a very fortunate position of having relatively simple hardware that can be built and improved fairly rapidly, and hardware that doesn't require a lot of power and doesn't require an awful lot of crew time. So consequently we have been able to fly on a fairly regular basis and have flown on at this stage six Shuttle flights. The first four of those were mainly hardware development flights, but this year we have flown, in '88 and early '89 we have flown on STS-26 and STS-29.

The results from these last two Shuttle flights where we had hardware that had been developed to do things the way we wanted it to be done were very exciting.

[Slide.]

This just summarizes in a nutshell what we now know to be the case, at least in the selected experiments that we have been able to perform thus far on the Space Shuttle. By going into microgravity, and I want to emphasize we still have a long way to go and we still haven't developed ultimate ways of doing all of this and are learning each time we go, but already it's clear that microgravity permits us to get crystals that are larger and in some cases large enough to do structures where structures were not possible before, much more uniform morphologies.

But the thing that is very, very exciting to us and our colleagues is that after these last two flights we now have very clear evidence that the internal molecular ordering of these crystals has been greatly enhanced. Now that's important because it means that in using these crystals we can move very quickly to determining complete precise structures of these target molecules in a way that was not possible before, and this is clearly going to be something that is going to be of building interest to the industrial affiliates that are now with our center, and I think it's going to create a great deal of excitement in the academic community once all this work is published.

[Slide.]

This slide lists I guess what are not necessarily what I would call concerns, because I feel like things are really going very well right now with the CCDS program in general and we are delighted in Birmingham with the way that ours is moving, but there are some things that I think we need to emphasize and constantly keep aware of.

One is regular access to space. If you take an industry by the pharmaceutical biotechnology industries, which are ones where the United States is still in the forefront, a week or a month is a long time in their research programs. If you have to wait six months or a year between flights, the level of interest is going to be very low.

The companies need to know that they can access space on a regular basis and a reliable basis and that that assurance is there when they start one of these long-range programs. Otherwise, it's going to be a more curiosity level interest rather than a real economic potential. It has to be a regular resource that they know they can access, and I think it has to be a resource that allows access in a variety of different ways, both to assure reliability and allow certain types of experiments to be performed.

There are certain things you can do great on the Space Shuttle, and there are other things that are going to require a much quieter environment, such as free fliers, and the Space Station is going to be fantastic for a lot of the things we would like to be doing where you have real time science going on like we do on the ground where we can run an experiment, analyze the results and turn around and rerun it.

All these methods of accessing space are important and of course need to be given very high priority. There needs to be an assurance of long-range government commitment to the commercial sector. Now I don't mean to imply that it's not there right now, but the companies that are involved with us are newcomers to this field and they don't really know how long this interest in really stimulating their involvement and making things fairly easy for them to be involved is going to be continued. It needs to be clear to industry that this is a long-range commitment that is going to be growing and that NASA and the government is committed to make sure space is commercialized.

There needs to be continued cooperation among the different divisions of NASA. In our program we have been working very closely between the Office of Commercial Programs and the Office of Space Science and Applications. The scientists that are involved with DuPont, with Upjohn and with Eli Lilly are every bit as outstanding as the ones from our academic institutions. Their science is on a level that is equal with science from non-commercial sectors. They make as big a contribution to the Office of Space Science and Applications as my academic colleagues, and this is very important for NASA to realize, all those at the Office of Commercial Programs. The science coming out of these programs impacts a lot of different divisions of NASA. We have had a lot of cooperation between the different divisions and that needs to be encouraged. It needs to be encouraged and stimulated because there is natural turf instinct that I think we all have to try to protect our own turfs and to scope them out, but we've got to be sure that this sort of cooperation continues.

Frank has already hit on the international cooperation aspect. There are protein crystal growth projects being planned by the Japanese, the Soviets are flying protein crystal growth, the European Space Agency has an aggressive program that is starting, and in biomedical sciences in general international cooperation is the rule of the day. There is an awful lot that is learned both ways by transferring back and forth.

In the commercial sense this clearly presents challenges of how we can have the best of the international cooperation without jeopardizing the proprietary preeminent stance that the American companies now enjoy.

All of these things I have listed up there, like I say, are not really concerns as much as they are things that I think we need to continue to give thought to and to give emphasis to. But overall I would conclude that the Centers for the Commercial Development of Space are doing exactly what they were envisioned to do.

They are bringing companies in that otherwise would be unlikely to be involved at this stage in the space program. They make it very easy for companies to get involved at the upper stage and to get their programs to a level where they can begin to evaluate what is going on, and they are beginning to accumulate the database that is going to be absolutely essential if someone a year from now is going to make a hard-nosed, long-range financial decision about what is to be gained by going into space.

All of these things I feel like at this stage can best be done through the kind of structure that has been assembled by the Centers for the Commercial Development of Space.

Thank you.

[The prepared statement of Dr. Bugg follows:]

Testimony to U.S. House of Representatives Committee on Science, Space and Technology, April 11, 1989

The Center for Macromolecular Crystallography at the University of Alabama at Birmingham was formed in 1985 as one of the first NASA-sponsored Centers for Commercial Development of Space. The Center was established to interface with industrial groups who are pursuing commercial applications of macromolecular crystallography, and who would be participants in efforts to develop techniques for growing crystals of proteins and other biological macromolecules under microgravity conditions.

Crystallography is a powerful method for determining the three-dimensional structures of complicated biological molecules. Crystallographic studies have played key roles in establishing the structural foundations of biochemistry and molecular biology, and for revealing structure/function relationships that are of importance in our undersanding of how enzymes, nucleic acids, and other macromolecules operate in biological systems. More recently, crystallographic studies of biological macromolecules have become of considerable practical interest to the pharmaceutical , biotechnology and chemical industries, as promising tools in drug design, protein engineering, and other applications.

The detailed information that can be learned from the three-dimensional structure of a protein is extremely useful in several ways. From the basic biomedical viewpoint, this information plays a critical role in our understanding of the way that enzymes, receptors, hormones, etc. function in biological systems. Within the pharmaceutical industry, protein structure information can be used to aid in the design of highly specific pharmaceutical agents. Since many drugs act by interacting with target proteins in biological systems, knowledge of the structure of a target protein can be used to tailor make compounds that selectively bind to target sites, and thereby inhibit the activity of the protein. For example, if a particular enzyme is required for the function of a target cell, the cell may be destroyed by designing a drug that "fits" the active site of the enzyme and blocks its catalytic activity.

Most of the drugs that are now available have been made by tedious trial and error methods. Hundreds or thousands of compounds are synthesized and tested in efforts to obtain inhibitors of key proteins within target cells. A more logical approach, which is the foundation of "rational drug design" is to obtain the complete three-dimensional structure of a target protein using the techniques of crystallography, and to then specifically design compounds that have the proper shape and distribution of chemical groups to bind tightly within key sites of the protein and thereby block its biological action.

A second highly promising commercial application of protein crystallography is in the area of protein engineering. Current techniques of molecular biology permit investigators to specifically alter protein molecules through site-directed mutagenesis, which is a technique for modifying the DNA molecules that code for the protein. Although the techniques involved in protein engineering are under intense development at this stage, it is generally accepted that these methods will prove to be of tremendous practical value for the design of entirely new types of enzymes that can be used as catalysts for mediating a variety of reactions, and for the design of biological modulators and other pharmaceutical agents that have carefully engineered physical and biological properties. As a general rule, the most promising approaches to protein engineering rely upon detailed structural information about the proteins of interest. At the present time, this sort of information can only be obtained by the techniques of protein crystallography.

The Center for Macromolecular Crystallography was established to stimulate commercial applications of protein crystallography, and to bridge academic research, NASA and industry. The Center has developed a multi-faceted program that provides facilities and expertise for crystal growth studies in space and on the ground; complete macromolecular structural studies; basic research in drug design based upon the results of protein crystallography; hardware and software systems for macromolecular crystallography; and protein engineering guided by protein crystallography. The wide range of services available through the Center have made it possible for pharmaceutical, biotechnology and chemical firms to become more actively involved in commercial applications of macromolecular crystallography. It is believed that this involvement will eventually lead to commercial applications of protein crystal growth in space.

The current program in the Center for Macromolecular Crystallography involves a wide range of crystallographic projects that are funded through more than 3 million dollars in grants and contracts from corporate sponsors, the National Cancer Institute, other agencies of the National Institutes of Health, the National Science Foundation, the American Cancer Society, the Leukemia Society of America, the Juvenile Diabetes Foundation, the State of Alabama and NASA. In addition, the Center is now receiving more than 5 million dollars of in-kind collaborative services from Industrial Affiliates of the Center. The Center has served as a major mechanism for facilitating access to space by companies that rely upon protein crystallography as part of their internal research programs.

At the present time, macromolecular crystallography is the only technique available for elucidating the atomic arrangements within large biological molecules. The information that can be gained from these crystallographic studies is of major importance for future advances in biomedical sciences, for the development of new pharmaceutical agents, and for other applications of commercial potential within chemical and biotechnology industries. The major bottleneck in the widespread development of this field is now protein crystal growth. It is extremely difficult to grow large, highly ordered crystals of most biological macromolecules. Recent protein crystal growth experiments performed by our Center using the space shuttle have demonstrated that the microgravity environment can be used effectively to obtain crystals that are larger, better formed, and more highly ordered than those grown on earth. Consequently, there is tremendous current interest among our colleagues in academic, industrial and government research laboratories in pursuing space experiments in protein crystal growth.

Our Center has served as a coordinator for performing protein crystal growth experiments on the space shuttle. We now have eleven Industrial Affiliates of the Center, including some of the major companies from the pharmaceutical, chemical and biotechnology industries. The companies now working with our Center are BioCryst, Burroughs-Wellcome, Dow Chemical Company, DuPont, Eastman Kodak, Eli Lilly, Genentech, Merck, Procter and Gamble, Schering-Plough and Upjohn. In addition, our Center is collaborating with scientists from several government laboratories and from twelve other universities. Our consortium of Co-Investigators recently performed 120 different protein crystal growth experiments on shuttle flights STS-26 and STS-29. These experiments provided several striking examples of how space can be used to produce crystals that are much better than the best that had been obtained in years of work on earth. Our most recent results indicate that some of the space-grown crystals are much more highly ordered at the molecular level than crystals of the same proteins grown on earth. This is important, since the precision with which molecular structures can be determined by crystallography is directly related to the internal order of the crystals. More ordered crystals will permit our industrial colleagues to accelerate their research programs that are directed at using protein crystallography in drug design, protein engineering and other commercial applications.

Our space experiments in protein crystal growth are still in an infant stage, and we have much to learn before we can adequately assess the long range potential of protein crystal growth in space. However, the results from our most recent experiments are exciting and promising, and our industrial partners are eager to pursue a wide range of new space experiments in protein crystal growth. If successful, the experiments that are planned over the next few years will have significant impact on forefront research efforts to produce new drugs for treating a wide range of diseases. Proteins that were studied by our Industrial Affiliates on STS-26 and STS-29 include major targets for the development of drugs for treating AIDS, cancer, cardiovascular disease, arthritis, diabetes, influenza, emphysema, lupus and growth defects. Although crystal growth is only one step in the research programs that are aimed at developing new classes of drugs by protein crystallography, it is a critical step. Consequently, the companies affiliated with our Center are eager to move as rapidly as possible to develop this very promising application of space.

The United States is the world leader in the pharmaceutical and biotechnology industries. One reason for this leadership position is that our universities have been at the forefront in basic biomedical research. The National Institutes of Health have done a superb job of fostering basic molecular biology and other disciplines that form the foundation of the pharmaceutical and biotechnology industries. In order to maintain this leadership position, it will be essential to maintain strong interfaces between our biomedical research universities and the pharmaceutical/biotechnology industries. Our Center, like the other Centers for Commercial Development of Space, serves as a focal point for bridging academic, government, nonprofit and industrial groups together to approach fundamental areas of research that will strengthen our competitive position worldwide. Centers for Commercial Development of Space are clearly accomplishing what Congress and NASA envisioned when the commitment to establish these Centers was made. It is unlikely that most of our Industrial Affiliates would be in a position to take advantage of the space program without our NASA-sponsored Center for Macromolecular Crystallography.

Routine access to space will be critical if we are to maintain momentum in this very promising area of research and serve the demands of our Industrial Affiliates. The pharmaceutical and biotechnology industries are extremely competitive, and basic biomedical research is advancing at an almost unbelievable rate. Research projects that require months or years between experiments will be of little interest in this rapidly evolving area of technology. Interest in space experimentation will be severely limited unless the investigators know that they can access space frequently and reliably. Accessibility is the critical factor, and a variety of mechanisms for performing microgravity experiments will be needed. We have done some very exciting experiments using the space shuttle, and we plan to continue taking advantage of both middeck and Spacelab opportunities. The space shuttle offers several significant advantages over alternate mechanisms for accessing space, including late loading of sensitive biological materials; rapid retrieval of samples; crew assistance; gentle reentry; and the potential for frequent flight opportunities. The introduction of extended-duration-orbiters will permit us to perform many protein crystal growth experiments that require more than a few days of microgravity. However, the space shuttle is not a suitable vehicle for those experiments that require several weeks of crystal growth, or a very quiet environment. These experiments would be best performed on free-fliers, launched either by expendable launch vehicles or by the shuttle. The space station will be ideal for many types of protein crystal growth experiments that require long duration, manned intervention, and on board analysis of samples. The space station will provide the capability of performing "real-time" research in a microgravity environment, in which experiments are performed, results are analyzed, and new experiments based upon these results are immediately initiated. All of these methods for accessing space must be given high priority if commercial development of space is going to become a reality.

Space research is expensive. Industry is especially interested in accessing space in order to pursue basic research projects that may be years away from product development and profitability. The microgravity environment of space is unique, and methods for accessing space should be considered national resources in the same category as the National Institutes of Health and our national laboratories. Like these other national resources, it is likely that government will need to continue to play a lead role in supporting the essential activities. Industry will use these resources if they are reliable, readily accessible and cost effective. The Centers for Commercial Development of Space provide excellent mechanisms for facilitating the involvement of U.S. industry in the space program. These centers will need long range commitments and continuing support from NASA in order to maintain viable interfaces with industry. It is imperative that the different divisions of NASA, such as the Office of Space Science and Applications and the Office of Commercial Programs, work closely together in the development of hardware and facilities that will assure optimum use of space by both academic and industrial scientists. International cooperation will also be essential in order to take full advantage of the scientific and commercial potential of space in a cost effective manner. It will be a major challenge for NASA to develop mechanisms for effective international cooperation, while maintaining proprietary leadership positions of American companies involved in space efforts.

I sincerely appreciate this opportunity to meet with the Committee on Science, Space and Technology. I am firmly convinced that space will eventually prove to be an important component in the future activities of pharmaceutical, chemical and biotechnology companies, and I am honored to play a minor role in the evolution of this process.

Biographical Sketch

Charles E. Bugg, Ph.D.

Charlie Bugg is Director of the Center for Macromolecular Crystallography, which is a NASA-sponsored Center for Commercial Development of Space located at the University of Alabama at Birmingham. He is also Professor of Biochemistry, and Associate Director of the Comprehensive Cancer Center in Birmingham. He received his B.S. degree from Duke University in 1962; his Ph.D. in Physical Chemistry from Rice University in 1965; and joined the faculty at the University of Alabama at Birmingham after two years of postdoctoral study at the California Institute of Technology. He is Editor-in-Chief of Acta Crystallographica, which is a series of journals published by the International Union of Crystallography, and he is a past-President of the American Crystallographic Association. He serves on several advisory committees for NASA, and the National Institues of Health. He has published more than 120 scientific papers, primarily in the area of crystallography. He is Principal Investigator of the project "Protein Crystal Growth in a Microgravity Environment", sponsored by NASA's Microgravity Science and Applications Division.

CENTER FOR MACROMOLECULAR CRYSTALLOGRAPHY

UNIVERSITY OF ALABAMA AT BIRMINGHAM

A NASA-SPONSORED CENTER FOR COMMERCIAL DEVELOPMENT OF SPACE

PROTEIN CRYSTALLOGRAPHY

A Technique for Determining the Three-Dimensional Structures of Biological Molecules

PROTEIN CRYSTALLOGRAPHY COMMERCIAL APPLICATIONS

- Basic Understanding of Biological Systems
- Rational Drug Design
- Protein Engineering

CENTER FOR MACROMOLECULAR CRYSTALLOGRAPHY

INDUSTRIAL GUEST INVESTIGATORS

BioCryst
Burroughs-Wellcome
Dow
Dupont
Eastman Kodak
Eli Lilly
Genentech
Merck
Procter & Gamble
Schering Plough
Upjohn

BIOCRYST, LIMITED

- Formed by Birmingham Business Leaders
- Pharmaceutical Development Using the Center for Macromolecular Crystallography
- Initial Capitalization - $5.2 Million
- Located in University-operated Incubation Facility

SPACE SHUTTLE EXPERIMENTS IN PROTEIN CRYSTAL GROWTH

STS-51D	April, 1985
STS-51F	July, 1985
STS-61B	November, 1985
STS-61C	January, 1986
STS-26	November, 1988
STS-29	March, 1989

RESULTS OF SHUTTLE EXPERIMENTS PROTEIN CRYSTAL GROWTH

- Larger Crystals
- More Uniform Morphologies
- More Highly Ordered at the Molecular Level

COMMERCIAL POTENTIAL OF SPACE

- Regular Access
  - Shuttle
  - Free-Fliers
  - Space Station
- Assurance of Long-Range Government Commitment
- Continued Cooperation Among Divisions of NASA
- International Cooperation

Mr. **Volkmer**. Thank you very much, Dr. Bugg.

Before we continue, Mr. Donley, the gentleman from California has to leave in a few minutes and he would like to ask some questions first. So I'm going to interrupt and let Norm ask some questions.

Mr. **Mineta**. Mr. Chairman, I appreciate that very much.

Mr. Rose, I just want to commend you for the work you're doing. Sometimes I think your task is sort of like shoveling sand against the tide given the enormity of the program, but I think your understanding of the program and what you're trying to do is really commendable and the development of these Commercial Centers for the Development of Space.

But I would like to take a different tact in front of the experts here today on materials science and ask about life sciences, if I might just digress a bit, and ask about what is happening in the field of life sciences. What are we doing to encourage companies in the private sector to have collaborative efforts with NASA as it relates to life science? We have heard some of the very exciting things that are being done in terms of the private sector and the materials science side, and I'm wondering what we are doing on life sciences in preparation for a Space Station?

Mr. **Rose**. Well, I'm not an expert, Mr. Mineta, on exactly all that is going on in the NASA's life sciences program, but they are preparing a fairly big program to carry out the necessary technology work that is going to be required to eventually pave the way if we should return to the Moon and if we should go to Mars. There is a lot of fundamental understanding of the physiological aspects of the human body that we don't know about.

So they are gearing up a very comprehensive program and will begin to fly a number of payloads in the not too distant future to begin to get answers, and they are going to need longer duration times. They are looking at some free flying options, they are looking at such as Amica and other types of potential commercial carriers that might come along in supporting of that research they are going to do.

This was an area that had been dormant for a while. We really didn't need it for the type of work in Shuttle, but even Shuttle, if we go to 16 days and longer, the understanding of what physiological effects on the proficiency of the astronauts to land after 16 days in weightlessness is an unknown, and we must create that information as well. So what I would call somewhat of a crash program is now being defined that we will begin to try to get that information so that we can build up with this extended duration orbiter capability, build up to a full 16-day capability.

Mr. **Mineta**. Well, within your area of commercial programs are you not also responsible in the area of life sciences?

Mr. **Rose**. Well, we have two other life science commercial centers, one at Penn State University and one at the University of Colorado, but their life sciences work is more I would say geared to the pharmaceutical type of activities associated with various hormones and enzymes and cell behavior that could be determined. In fact, I would just like to make a comment because I think it's a reasonably big breakthrough. Genentech has officially gone on record of joining our center at Penn State University in a fairly broad way, very much like the 3M program where they see a great potential in a major research investigation using microgravity.

As far as the human physiological aspects of space itself and what it does to the people, some of these will perhaps fall out because we recognize in some of the research, for instance, and I think the data is common knowledge now, it would appear that the body suppresses the release of growth hormone. The pituitary just doesn't release the hormone in space for some reason in microgravity. That is one of the reasons it's felt that we experience bone loss and we experience loss of calcium. Maybe we can get a handle through doing that type of research to better understand the physiological effects that space does have, and by doing that we can learn a lot more about things we might be able to treat on the ground. So in a way we are directly supporting that.

Mr. MINETA. Very quickly, have you had a chance to see the National Research Council report that just came out?

Mr. ROSE. Yes. I have had a brief time to glance through it.

Mr. MINETA. Any comments on it?

Mr. ROSE. It depends on the ground rules in which you look at the data. The conclusions they drew were very factual based on their ground rules.

Mr. MINETA. All right. Thank you very, very much, and I apologize for having to leave.

Mr. VOLKMER. Thank you, Norm.

Mr. Donley.

STATEMENT OF EDWARD DONLEY, CHAIRMAN, EXECUTIVE COMMITTEE, AIR PRODUCTS AND CHEMICALS, INC., ALLENTOWN, PA, AND CHAIRMAN, COMMERCIAL PROGRAMS ADVISORY COMMITTEE, NASA

Mr. DONLEY. Thank you, Mr. Chairman.

I have submitted a formal statement for the record, and I appreciate the opportunity to do that.

I'm Chairman of the Executive Committee of Air Products and Chemicals, Incorporated, and also Chairman of the Commercial Programs Advisory Committee which was created within NASA about a year ago.

We recruited about a dozen CEO's of distinguished American companies and CEO's of four important American Universities to serve on that committee. We have been meeting frequently during the past year, and we will meet again tomorrow, and expect to have a report to submit to NASA management and of course to this Committee by the end of May.

Now what are the general outlooks that we have developed from our examination and discussion of these subjects?

First of all, we are of the view that the competitiveness of American companies in world markets is critically important to the well being of this country, and we believe that the key to the competitiveness of American companies is our American technology.

Space technology leadership provides overall technology leadership, and technology leadership in general is closely dependent upon and interlinked with the quality of our educational systems at all levels from K through 12 and particularly from higher education in science and technology fields.

So that's the first point that our report will deal with, the enhancement of U.S. competitiveness as a result of the space activity and the interlocking of the private sector and the public sector in that endeavor.

The second point that we have become conscious of and concerned about is that we believe we need a much better coordination among the multiplicity of government agencies who deal with the space issues, and we are hopeful indeed that the National Space Council will fulfill that needed role.

What are the opportunities that we believe exist in the development of space commerce? Well, my colleagues have enunciated many of those. There are unique physical characteristics in space, and those may very well permit the creation of products which mankind has never seen before, as we have heard in the last few minutes.

But the space effort isn't everything that happens in space. Lifting vehicles into space requires enormous complex technologies here on earth, and there is an opportunity in the development of those technologies to find commercial applications for the technologies as well which will as that continues in the future enhance the competitiveness and productivity of our country.

The challenges are the government must take the lead. The government must provide better interagency coordination and the government must assure the private sector that there is a stable, ongoing, predictable space program.

And, further, the government has to create an aura which invites large corporations and small corporations as well to come into this arena and participate in this space program, and because of course the private sector is motivated by profits, the government has to base that invitation upon the idea that it will be in the self-interest of those corporations to come in and commit their capital and their human resources.

Now can we have confidence that such a program is going to lead to good things for this country? I say you bet we can, and I say that based upon my own personal experience.

I retired two years ago as Chairman of Air Products and Chemicals after 40 years in that company. When I came to the company it had 10 employees and I was the 11th. It now has 12,000 employees, $2.5 billion annual sales, the market value of the stock on the New York Stock Exchange is $2.5 billion. Everyone has benefited from that development. The shareholders, the employees, the communities where we operate, our suppliers and our customers and the Nation as a whole have benefited.

Now what brought it about? Starting more than 30 years ago it was decided in various agencies of the U.S. Government that we would use cryogenic* for propulsion of defense and space vehicles, and research programs were awarded on a competitive basis, most of them to our company for research, development and demonstration on how to produce and how to handle these cryogenic fluids.

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*See appendix 10, p. 1254.

Now today there exists throughout the free world an approximately $8 billion world market for selling industrial gases which are all based upon the production and distribution and handling and processing of cryogenic fluids. In our company two percent of our sales go to the government, but 98 percent go to the private sector.

I think it's a model that shows where we create the environment to bring particularly small entrepreneurial companies, but also large corporations into this marriage with government that we can collectively then, if the atmosphere is right, develop relationships and technologies which the private sector can most effectively transfer the technology into the private sector itself.

I'm firmly convinced that out across this country today there are hundreds and maybe thousands of small Air Products type companies of the future which if we can find the right environment to bring in their skills and their capital and their human resources that we will develop dozens or hundreds of enterprises of this kind in the future which will benefit a whole society.

That the gist of my remarks in my formal submission, Mr. Chairman. I thank you and I'll be happy to answer any questions when you get to that point if you wish.

[The prepared statement of Mr. Donley follows:]

Statement of

EDWARD DONLEY

Chairman, NASA Commercial Programs Advisory Committee

before the

Subcommittee on Space Science and Applications

Committee on Science, Space and Technology

House of Representatives

April 11, 1989

Mr. Chairman and Members of the Subcommittee:

I am pleased to be given the opportunity to appear before you to discuss the very important topic of the commercial development of space. In 1988, I was asked by NASA to chair a Commercial Programs Advisory Committee. In accepting that challenge, we recruited a group of very able individuals with diverse business and higher education backgrounds from many different organizations. Our job is to advise NASA on how it can implement the commercial space initiatives issued by President Reagan early in 1988 and to comment on the overall role of the Nation's commercial space policy.

Our Committee has met three times—in Washington in July 1988 and February 1989, and at the Kennedy Space Center in October 1988. The membership of the Commercial Programs Advisory Committee is different from other committees formed to examine this topic in that it is comprised of business leaders and university leaders from around the Nation who have a working knowledge but mostly not a primary responsibility for activities in the space arena. In this way, we are working to get the necessary business acumen characteristic of corporate and academic chief executive officers and to apply that knowledge base to the emerging potential of space commerce.

The Committee's primary challenge is in defining the role and responsibilities of both government and the private sector with an emphasis on the promotion of private capital investment in the area of space. We are meeting again this evening and tomorrow to discuss the final recommendations of our report which will be released later this spring. The primary thrust of the report will be included in remarks which I am scheduled to make on May 25th before the Washington Space Business Roundtable.

Before I share with you my thoughts on the Committee's activities and the challenge for government, industry, and education sectors, I would like to provide a perspective of the overall backdrop in which space commerce will develop.

Commercial development of space is relatively new as a government policy area. In the quarter of a century since we began the space program, our goals have been largely fixed on scientific and foreign policy considerations. The government became the deep pocket to fund a mighty national commitment to lead the world in space exploration. Space commerce beckons us toward an entirely different kind of world leadership that requires much different policy perspectives.

A second issue is the emergence of a world marketplace — the growth of international competitiveness on the one hand and the forceful movement toward global interdependence on the other. When we first ventured into space, we stood as a towering economic force. While we remain the strongest, richest, and most scientifically advanced nation on earth, we no longer dominate the world economy — nor do we have an exclusive hold on space development.

And, there is one more thing to be considered. The traditional approaches which have characterized large-scale, complex and costly undertakings in the past may not be valid in unlocking the potential of space commerce. We will be wise to explore alternative means for capitalizing, structuring relationships, and creating new incentives for private sector participation in such endeavors. The time has come to seek innovative approaches to encouraging the commercial development of space. Not just because of large federal deficits, although that is reason enough, but also because it makes no sense for government and industry to be adversaries in this process.

Much has been written about the United States competitiveness in the world marketplace. We must understand that is the most important aspect of economic space activities. In June 1983, we in the Business-Higher Education Forum, of which I have been chairman, had the opportunity to present a report to President Reagan in the Oval Office with one particular recommendation — society must develop a consensus that industrial competitiveness on a global scale is crucial to our social and economic well-being. I am encouraged by the government response to this challenge and its focus on this notion of international competitiveness.

The most critical factors affecting our Nation's competitiveness are the cost of capital, the cost of labor, and the comparative sophistication of our technology. While we continue to work on policies that would make us more competitive in the areas of labor and cost of capital, America's trump card is — and will continue to be — our capacity to stay ahead in the development and application of new technologies, and in no area is technological leadership more important than in space. Leadership in technology requires leadership in space. In turn, leadership in space requires a serious and realistic set of initiatives in cooperation with and among the public and private sectors. Space also offers the United States the rallying point for technological advances in the areas of science and education.

The most recent National Space Policy, issued by President Reagan in February 1988, confirms the commitment of the Nation to the overall goal of the commercial development of space. That policy focuses on three areas of space: civil, military, and commercial. While each of these sectors has individual objectives and policy initiatives, it is critical that the interaction of the policies and their implementation be closely coordinated for the United States to be internationally competitive in the area of space.

I applaud the Congress and the Administration in its establishment of the National Space Council with its critical role of providing leadership in space. Today, commercial space activity is conducted in many government functions including NASA, Department of Commerce, Department of Transportation, Environmental Protection Agency, Department of State, National Science Foundation, and others. It is imperative that the National Space Council provide strong leadership in implementing the commercial space policies established by President Reagan and in recasting these policies as necessary to be responsive to the current environment and marketplace.

With this backdrop in mind, I would like to focus on three overarching areas that will be critical to the successful development of space commerce.

First, for commercial development of space to blossom in a meaningful and significant way, there must exist innovative ideas for the development of products and services utilizing the physical attributes of space such as vacuum and microgravity. We as a Nation, and NASA in particular, must continue to strive for excellence in nurturing innovation in product research through such mechanisms as the Centers for the Commercial Development of Space. Commercial and private investment in other sectors involved in space will follow the lead of a strong commercial market in products and services that can be profitably used on earth or in space.

New space-based products represents only one of the market segments that has developed over time. The communications satellite business is an excellent example of a commercial space activity that has successfully developed through the initial work of the government. This is the only true commercial space activity that is viably profitable today. Commercial space has great potential -- but it is just that -- potential. It is not yet reality. Turning potential into reality requires the government to take the lead role in a partnership with industry and the higher education sector to help tap that potential and develop the next wave of commercial space businesses.

Second, as Centers for the Commercial Development of Space and other government-encouraged research and development activities generate new ideas for products and services in space, United States policies must provide for assured access to the space environment in which they are to be carried out. The single, most important factor in the successful implementation of commercial space activities is reliable, competitively priced access to space.

We must develop and utilize alternative space transportation systems in addition to the Space Shuttle. These systems should be focused on the market needs of each of the individual emerging space commerce activities. Some of the alternatives include existing domestic expendable launch vehicles and new, more cost-effective systems, both unmanned and man-rated. These systems are based on the extension of known technologies and applications of new technologies such as those embodied in Advanced Launch System and the National Aero-Space Plane. Here is where it is clear that the military and civil sectors' combination of strengths are very important for the commercial development of space. The military's purchase of expendable launch vehicles and the access policies for commercial use of launch facilities are critical to the success of developing low-cost, assured access to space.

And third, but no less important than the other two factors, is the establishment of space infrastructure for the development and production of space-based products. Once ideas have been developed and carried into space through effective space transportation systems, the ongoing requirement for manufacturing space products needs to be addressed. This activity needs to be developed through Space Station Freedom and other platforms such as the commercially developed space facility, and innovative and productive use of the shuttle's external tank. But the government needs to be upfront and committed to assuring that those platforms will, in fact, be available. If not, the emerging commercial space sectors will not be successful.

Now, what are the challenges that we need to understand in order to be successful? First and most important, and I believe highest on the mind of many of the Subcommittee members, is how is the government going to pay for all these worthwhile initiatives? How are we to undertake these major initiatives in the face of large deficits?

First, I want to re-emphasize that the government needs to take the lead, but it does not need to be alone in that leadership role. It must be there with a new spirit of government and industry collaboration, one of mutual trust and progress towards a single goal.

Second, we must strive for improved intergovernmental cooperation. This can be provided by the National Space Council if it moves to be the focus for developing commercial, civil, and military space policies.

Third, policies must have stability so that industry can feel confident in dealing with the government as a partner in activities and ventures to make the Nation more competitive. Other nations have been able to accomplish this and I believe the United States can also demonstrate our abilities in this area. To that end, the government needs to have revised procurement approaches that foster multiyear commitments and encourage private sector investment. Notice that I said private sector investment not just financing. There is a great deal of difference between the two and let me take a moment to explain my understanding of the concept and my personal experience of how a company called Air Products and Chemicals was able to develop a successful business through the government's lead role.

In the mid-1950s, liquid hydrogen and to some extent liquid oxygen were little more than laboratory experiments waiting to be commercialized. The U.S. Air Force was studying hydrogen for several applications and its high energy content was well known. But in its normal gaseous state it could not be used in flight vehicles. Research and development sponsored by the Air Force resulted in processes for liquifying hydrogen to reduce the volume. However, another problem remained, liquid hydrogen was available only in laboratory amounts - grams per day. Yet the ambitious Air Force programs required testing in flight quantities of tens of tons per day. Air Products undertook the challenges of developing processes for the large quantity production of liquid hydrogen.

In about three years time, the company scaled up liquid production from grams to tons per day and demonstrated the feasibility of large-scale production incorporating different technologies and different feedstocks. Subsequently, the company constructed three more liquid hydrogen facilities to supply NASA's growing Space Shuttle requirements and has invested private capital in those facilities to supply NASA the liquid hydrogen propellant — as opposed to the government investing in a facility to provide the product.

Let's examine this case study in light of the current debate over the several private initiatives suggested by the Office of Management and Budget. First, there was no commercial market for liquid hydrogen when the government encouraged Air Products to invest in facilities that would supply the product. However, since that time Air Products and now others in the industrial gas industry have developed a worldwide market that is several times the government requirements. This market has generated new technologies, new employment, and tne United States is now the world leader in liquid hydrogen.

I believe we must keep in mind the histories like Air Products' and many other corporations and organizations throughout the Nation when we undertake endeavors to develop a privately financed or capitalized facility for commercial space activities. Government and industry should work together—not as adversaries. They should be trusting of each other. Such partnerships can yield national benefits in the future as they have in the past.

The most cost-effective way to accelerate space commerce is to shift government from the role of provider to that of the procurer — and to induce industry through adequate financial incentives to fill the provider role. There are few other options for spreading and lowering the costs or for inspiring private initiatives and investment.

We must accept the fact that commercial space development will not take place under conditions usually associated with a completely market-free approach. The markets that have been successful in the past were not developed that way and the successful markets of the future will not be developed that way. Traditional, full cost development will produce more satellites but few, if any, new significant commercial space enterprises. Our friends overseas understand this concept and we cannot fail to explore the possibilities of such arrangements.

The Commercial Programs Advisory Committee is working on these and other specific recommendations to be presented to the Nation's space community. We no longer have the luxury of one-dimensional or linear approaches to achieving many of our goals — whether the goals of business and industry, the goals of science and technology, or the goals of a Nation and its people. That was possible in a different time and perhaps when the world was a different place. Competitiveness and a global economy have changed all that. It's not just that the rules of the game are different but the game itself is different. We know that the competition for space development will be a different business to be approached differently than we approached our goals for space exploration and scientific discovery but a few short years ago.

Mr. Chairman, you and the distinguished members of this Subcommittee, play a critically important role in developing and supporting policies for the successful commercial development of space. We encourage you to continue to be open-minded and far-reaching in your thoughts and support for this most important new era.

Thank you.

Mr. VOLKMER. Thank you, Mr. Donley.

Mr. Schmidt.

STATEMENT OF CHARLES A. SCHMIDT, VICE PRESIDENT AND GENERAL MANAGER, ASTRO-SPACE DIVISION, GENERAL ELECTRIC, HIGHTSTOWN, NJ, AND FORMER CHAIRMAN, WORKING GROUP COMMERCIAL SPACE ADVISORY COMMITTEE TO THE FORMER SECRETARY OF COMMERCE

Mr. SCHMIDT. Good afternoon, Mr. Chairman and members of the committee. I'm Charles Schmidt, Vice President and General Manager of GE Astro-Space Division. I'm here today to speak on the report of the Commercial Space Advisory Committee.

This committee was authorized and constituted by the Department of Commerce by the Honorable C. William Verity, the former Secretary of Commerce. The initial meeting of the committee was convened on August 10th, in 1988 at the Department of Commerce.

Mr. Ed Hood, Jr., Vice Chairman of General Electric was asked to chair this Blue Ribbon committee whose members represented a broad cross-section of direct and indirect space activity and interests, including the Governors of the States of Hawaii and Florida and the CEOs of AT&T Bell Labs, Cigna, Cray Research, Dresser Industries, General Dynamics, 3M and UTC and top executives of GM Hughes, Westinghouse, Kimberly Clark, Argonne National Laboratory and the Young Astronauts Council.

The objective of this committee was to examine the major factors relevant to the development and promotion of an effective U.S. commercial space industry. The committee's report was to embody the frank views and conclusions of the industrial and private sector to serve as a guide toward creating a productive relationship between government and industry in the pursuit of commercial space markets.

The underlying concerns for the committee's deliberations were such as issues as:

What will it take for the U.S. industry to remain competitive in the commercial space markets, both existing and potential;

What cooperation do U.S. companies need to compete with foreign government owned companies;

What are the barriers to U.S. private industry to entering space markets; and

What will it take to create an environment which will allow for full use by U.S. industry of quality space research.

These are other pertinent issues are addressed in the final report of this committee, and I ask your permission to submit that report to this Committee as a subject of my summary remarks, although I didn't have 200 copies of it.

Mr. VOLKMER. That's all right.

Mr. SCHMIDT. At the conclusion of that first committee meeting, Chairman Hood recapped the committee's decision to establish a working group made up of representatives of the principals who should meet several times to develop thoughts and ideas for policy recommendations with respect to government leadership, sponsorship and support for commercial space technology development.

The themes described as the central issues for recommendations dealt with the roles of government and the evolution of commercial space opportunity from seed corn technology to space demonstrations to operational systems.

The committee listed several specific areas to characterize potential government participation as follows:

The government as an R&D agent; as a customer; as a service provider; a regulator; an international negotiator on the level playing field issue; a resolver of uninsurable liabilities; and an establisher of priorities.

Mr. Hood asked me to chair a working group and produce a preliminary report. The group was established and met several times to brainstorm the issues and establish additional issues, concerns and analogies.

The underlying and contributive factors leading to the conclusions and recommendations of the report are that space is still a world frontier with immense strategic importance to world leadership in every phase of government organizational activity. One need not reflect too deeply to realize the tremendous impact that this 30-year-old endeavor has produced in military, political, scientific and commercial activity. But as far as we have come, we have only just approached the threshold of what will be.

These are not the isolated musings of an abstract visionary, but the testimony of developed and developing countries from every continent.

The report concludes that the commercial aspects of space are broad ranging and its potential enormous, but the realization of robust commercial activity requires the satisfaction of fundamental commercial principles, that is, the technology is demonstrable and practical, a market for the product exists, the risk can be bounded and the investment is matched by reasonably predicted appropriate reward. The absence of any of these factors drastically constrains significant commercial activity.

The report documents committee conclusions as to necessary government activities to define, support and stimulate the private sector in evolving scientific vision and speculation to viable commercial opportunities. Further, this report contains a total of 16 specific recommendations for government action.

Since the economic well being of the U.S. citizenry is a tightly coupled function of the economic strength of its private sector, it is right and proper for the government to spawn development that will benefit its citizenry and it has done so for many, many years in many fields of endeavor with great success, even in commercial space.

The concern of the committee is that despite world leadership in many areas of space technology and application, the present condition of government-sponsored commercial space related technology and development has deteriorated and is today lagging foreign efforts.

Although the airplane is often mentioned, and was mentioned here today, as an example of government development initiatives transitioning to a strong and vigorously healthy commercial industry, we can cite an even more relevant case with the commercial satellite industry.

From Project Score through Echo, Relay and other proof-of-concept NASA-sponsored programs came today's thriving U.S. commercial developers whose products dominate the world market, are the highest performance design and regularly offer the user the lowest price. The economic returns to the United States for this excellent development are enormous.

The report's recommendations are what we believe to be the necessary ingredients to repeat this economic success in such other potential, yet presently highly speculative commercial space markets as remote sensing, position determination and reporting, facility and support services and material process development and manufacturing.

Our conclusion is that these commercial space business candidates require the same intensity, focus and leadership provided by the Government in the commercial communications scenario.

The dilemma of the fledgling and struggling commercial launch industry presents another concern of the committee, that is the unlikely success of U.S. companies competing with countries and consortia of countries for domestic and international payloads.

Despite available expertise, technology and considerabe investment by major U.S. companies to enter this market, the overwhelming resolve of foreign national interest and flexibility have to date frustrated the efforts the U.S. launch suppliers to effectively compete.

The report recommends that the U.S. Government develop a strategy to promote the creation of a fair trade environment for space goods and services, that is assume the role as the guarantor of a level playing field for the U.S. commercial space industry.

This recommendation, like others, is predicated on action by the government to provide institutional support through:

The development of a table and enduring commitment by both the President and Congress to encourage and nurture commercial space development;

The appointment of a Cabinet level official as the focal point for policy advocacy;

The establishment of a permanent industry committee representing a cross-section of the U.S. space industry to advise the Cabinet level official; and

The forging of definitions related to the responsibilities of the various government agencies and how they will execute their responsibilities concerning space business.

These steps are the bedrock for effective economic development of near-term and latent commercial space ventures.

Since insufficient time exists to treat in depth each of the recommendations, I would like to speak on another of those dealing with the government in its role as customer. Buying government space needs and services on commercial terms is a powerful way to stimulate the private sector toward innovative, cost-effective offerings to satisfy government demands.

As the government acts to fulfill the existing space policy dictum to purchase commercially available space services to the fullest extent possible, the response of the private sector will be to increase investment to be better positioned to participate in competitive offerings.

The U.S. Government has been a good customer for commercial communications services for years and in the still developing areas of commercial endeavor referenced in this report it will be the dominant customer for some time to come. We believe that a new commitment and subsequent action to implement commercial space activity wherever possible through the creation of commercially relevant procurement standards which address the entire spectrum of prospective commercial supply will materially energize the private sector to broaden its financial commitment.

The disappointment and critical commentary registered in the report springs from the irony that our enviable position in space technology is not being utilized and focused toward utilitarian commercial goals.

The committee supports manned space efforts, but not to the detriment and virtual exclusion of commercial economic space development. We believe that more attention must be given to other sectors of space research and development.

Technology is the fuel that will keep our space program and primacy robust. The partnership and propositions expounded in the committee's report will produce the kind of positive solutions sought by both government and industry.

This subcommittee knows that space is a high stakes game better than most, but the facts are if the U.S. is to maintain its leadership and reap its rewards, it will take stable and durable government advocacy leadership and involvement in cooperation and partnership with the private sector to achieve again what that combination has accomplished so often in the past.

Thank you.

[The prepared statement of Mr. Schmidt follows:]

STATEMENT OF C. A. SCHMIDT
VICE PRESIDENT AND GENERAL MANAGER
ASTRO-SPACE DIVISION
ON THE REPORT OF THE
COMMERCIAL SPACE ADVISORY COMMITTEE
FOR THE
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

APRIL 11, 1989

THE COMMERCIAL SPACE ADVISORY COMMITTEE WAS AUTHORIZED AND CONSTITUTED BY THE DEPARTMENT OF COMMERCE BY THE HONORABLE C. WILLIAM VERITY THE FORMER SECRETARY OF COMMERCE. THE INITIAL MEETING OF THIS COMMITTEE WAS CONVENED ON AUGUST 10, 1988, AT THE DEPARTMENT OF COMMERCE.

MR. EDWARD E. HOOD, JR., VICE CHAIRMAN OF GENERAL ELECTRIC WAS ASKED TO CHAIR THIS BLUE RIBBON COMMITTEE WHOSE MEMBERS REPRESENTED A BROAD CROSS SECTION OF DIRECT AND INDIRECT SPACE ACTIVITY AND INTERESTS, INCLUDING THE GOVERNORS OF THE STATES OF HAWAII AND FLORIDA, THE CEO'S OF AT&T BELL LABS, CIGNA, CRAY RESEARCH, DRESSER INDUSTRIES, GENERAL DYNAMICS, 3M, AND UTC AND TOP EXECUTIVES OF GM HUGHES, WESTINGHOUSE, KIMBERLY CLARK, ARGONNE NATIONAL LABORATORY AND THE YOUNG ASTRONAUTS COUNCIL.

THE OBJECTIVE OF THIS COMMITTEE WAS TO EXAMINE THE MAJOR FACTORS RELEVANT TO THE DEVELOPMENT AND PROMOTION OF AN EFFECTIVE U.S. COMMERCIAL SPACE INDUSTRY. THE COMMITTEE'S REPORT WAS TO EMBODY THE FRANK VIEWS AND CONCLUSIONS OF THE INDUSTRIAL AND PRIVATE SECTOR TO SERVE AS A GUIDE TOWARD CREATING A PRODUCTIVE RELATIONSHIP BETWEEN THE GOVERNMENT AND INDUSTRY IN THE PURSUIT OF COMMERCIAL SPACE MARKETS.

THE UNDERLYING CONCERNS FOR THE COMMITTEE'S DELIBERATIONS WERE SUCH ISSUES AS:

- WHAT WILL IT TAKE FOR THE U.S. INDUSTRY TO REMAIN COMPETITIVE IN THE COMMERCIAL SPACE MARKETS BOTH EXISTING AND POTENTIAL.
- WHAT COOPERATION DO U.S. COMPANIES NEED TO COMPETE WITH FOREIGN GOVERNMENT OWNED COMPANIES.
- WHAT ARE THE BARRIERS TO U.S. PRIVATE INDUSTRY TO ENTERING SPACE MARKETS.
- WHAT WILL IT TAKE TO CREATE AN ENVIRONMENT WHICH WILL ALLOW FOR FULL USE BY U.S. INDUSTRY OF QUALITY SPACE RESEARCH.

THESE AND OTHER PERTINENT ISSUES ARE ADDRESSED IN THE FINAL REPORT OF THIS COMMITTEE, AND I ASK YOUR PERMISSION TO SUBMIT THAT REPORT TO THE COMMITTEE AS THE SUBJECT OF MY SUMMARY REMARKS.

AT THE CONCLUSION OF THAT FIRST COMMITTEE MEETING, CHAIRMAN HOOD RECAPPED THE COMMITTEE'S DECISION TO ESTABLISH A WORKING GROUP MADE UP OF REPRESENTATIVES OF THE PRINCIPALS WHO SHOULD MEET SEVERAL TIMES TO DEVELOP THOUGHTS AND IDEAS FOR POLICY RECOMMENDATIONS WITH RESPECT TO GOVERNMENT LEADERSHIP, SPONSORSHIP AND SUPPORT FOR COMMERCIAL SPACE TECHNOLOGY DEVELOPMENT.

THE THEMES PRESCRIBED AS THE CENTRAL ISSUES FOR RECOMMENDATION DEALT WITH THE ROLES OF GOVERNMENT IN THE EVOLUTION OF COMMERCIAL SPACE OPPORTUNITY FROM SEED CORN TECHNOLOGY TO SPACE DEMONSTRATIONS TO OPERATIONAL SYSTEMS.

THE COMMITTEE LISTED SEVERAL SPECIFIC AREAS TO CHARACTERIZE POTENTIAL GOVERNMENT PARTICIPATION AS FOLLOWS:

THE GOVERNMENT AS:

- AN R&D AGENT
- A CUSTOMER
- A SERVICE PROVIDER
- A REGULATOR
- AN INTERNATIONAL NEGOTIATOR ON THE LEVEL PLAYING FIELD ISSUE
- A RESOLVER OF UNINSURABLE LIABILITIES
- AN ESTABLISHER OF PRIORITIES

MR. HOOD ASKED ME TO CHAIR A WORKING GROUP AND PRODUCE A PRELIMINARY REPORT.

THE GROUP WAS ESTABLISHED AND MET SEVERAL TIMES TO BRAINSTORM THE ISSUES AND ESTABLISH ADDITIONAL ISSUES, CONCERNS AND ANALOGIES.

THE UNDERLYING AND CONTRIBUTIVE FACTS LEADING TO THE CONCLUSIONS AND RECOMMENDATIONS OF THE REPORT ARE THAT SPACE IS STILL A WORLD FRONTIER WITH IMMENSE STRATEGIC IMPORTANCE TO WORLD LEADERSHIP IN EVERY PHASE OF GOVERNMENT ORGANIZATIONAL ACTIVITY. ONE NEED NOT REFLECT TOO DEEPLY TO REALIZE THE TREMENDOUS IMPACT THAT THIS 30 YEAR OLD ENDEAVOR HAS PRODUCED IN MILITARY, POLITICAL, SCIENTIFIC AND COMMERCIAL ACTIVITY. BUT AS FAR AS WE HAVE COME, WE HAVE ONLY JUST APPROACHED THE THRESHOLD OF WHAT WILL BE.

THESE ARE NOT THE ISOLATED MUSINGS OF AN ABSTRACT VISIONARY, BUT THE TESTIMONY OF DEVELOPED AND DEVELOPING COUNTRIES FROM EVERY CONTINENT.

THE REPORT CONCLUDES THAT THE COMMERCIAL ASPECTS OF SPACE ARE BROAD RANGING AND ITS POTENTIAL ENORMOUS, BUT THE REALIZATION OF ROBUST COMMERCIAL ACTIVITY REQUIRES THE SATISFACTION OF FUNDAMENTAL COMMERCIAL PRINCIPLES, I.E., THE TECHNOLOGY IS DEMONSTRABLE AND PRACTICAL, A MARKET FOR THE PRODUCT EXISTS, THE RISK CAN BE BOUNDED AND THE INVESTMENT IS MATCHED BY REASONABLY PREDICTED APPROPRIATE REWARD. THE ABSENCE OF ANY OF THESE FACTORS DRASTICALLY CONSTRAINS SIGNIFICANT COMMERCIAL ACTIVITY.

THE REPORT DOCUMENTS COMMITTEE CONCLUSIONS AS TO NECESSARY GOVERNMENT ACTIVITIES TO DEFINE, SUPPORT AND STIMULATE THE PRIVATE SECTOR IN EVOLVING SCIENTIFIC VISION AND SPECULATION TO VIABLE COMMERCIAL OPPORTUNITIES. FURTHER, THIS REPORT CONTAINS A TOTAL OF 16 SPECIFIC RECOMMENDATIONS FOR GOVERNMENT ACTION.

SINCE THE ECONOMIC WELL BEING OF THE U.S. CITIZENRY IS A TIGHTLY COUPLED FUNCTION OF THE ECONOMIC STRENGTH OF ITS PRIVATE SECTOR, IT IS RIGHT AND PROPER FOR THE GOVERNMENT TO SPAWN DEVELOPMENT THAT WILL BENEFIT ITS CITIZENRY AND IT HAS DONE SO FOR MANY, MANY YEARS IN MANY FIELDS OF ENDEAVOR WITH GREAT SUCCESS--EVEN IN COMMERCIAL SPACE! THE CONCERN OF THE COMMITTEE IS THAT DESPITE WORLD LEADERSHIP IN MANY AREAS OF SPACE TECHNOLOGY AND APPLICATION, THE PRESENT CONDITION OF GOVERNMENT-SPONSORED COMMERCIAL SPACE RELATED TECHNOLOGY AND DEVELOPMENT HAS DETERIORATED AND IS TODAY LAGGING FOREIGN EFFORTS.

ALTHOUGH THE AIRPLANE IS OFTEN MENTIONED AS AN EXAMPLE OF GOVERNMENT DEVELOPMENT INITIATIVES TRANSITIONING TO A STRONG AND VIGOROUSLY HEALTHY COMMERCIAL INDUSTRY, WE CAN CITE AN EVEN MORE

RELEVANT CASE WITH THE COMMERCIAL SATELLITE INDUSTRY. FROM PROJECT SCORE THROUGH ECHO, RELAY, AND OTHER PROOF-OF-CONCEPT NASA-SPONSORED PROGRAMS, CAME TODAY'S THRIVING U.S. COMMERCIAL DEVELOPERS WHOSE PRODUCTS DOMINATE THE WORLD MARKET, ARE THE HIGHEST PERFORMANCE DESIGNS AND REGULARLY OFFER THE USER THE LOWEST PRICE.

THE ECONOMIC RETURNS TO THE U.S. FOR THIS EXCELLENT DEVELOPMENT INVESTMENT ARE ENORMOUS.

THE REPORT'S RECOMMENDATIONS ARE WHAT WE BELIEVE TO BE THE NECESSARY INGREDIENTS TO REPEAT THIS ECONOMIC SUCCESS IN SUCH OTHER POTENTIAL, YET PRESENTLY HIGHLY SPECULATIVE, COMMERCIAL SPACE MARKETS AS REMOTE SENSING, POSITION DETERMINATION AND REPORTING, FACILITY AND SUPPORT SERVICES, AND MATERIAL PROCESS DEVELOPMENT AND MANUFACTURING. OUR CONCLUSION IS THAT THESE COMMERCIAL SPACE BUSINESS CANDIDATES REQUIRE THE SAME INTENSITY, FOCUS AND LEADERSHIP PROVIDED BY THE GOVERNMENT IN THE COMMERCIAL COMMUNICATIONS SCENARIO.

THE DILEMMA OF THE FLEDGLING AND STRUGGLING COMMERCIAL LAUNCH INDUSTRY PRESENTS ANOTHER CONCERN OF THE COMMITTEE, I.E., THE UNLIKELY SUCCESS OF U.S. COMPANIES COMPETING WITH COUNTRIES AND CONSORTIA OF COUNTRIES FOR DOMESTIC AND INTERNATIONAL PAYLOADS.

DESPITE AVAILABLE EXPERTISE, TECHNOLOGY AND CONSIDERABLE INVESTMENT BY MAJOR U.S. COMPANIES TO ENTER THIS MARKET, THE OVERWHELMING RESOLVE OF FOREIGN NATIONAL INTEREST AND FLEXIBILITY HAVE TO DATE FRUSTRATED THE EFFORTS OF U.S. LAUNCH SUPPLIERS TO EFFECTIVELY COMPETE.

THE REPORT RECOMMENDS THAT THE U.S. GOVERNMENT DEVELOP A STRATEGY TO PROMOTE THE CREATION OF A FAIR TRADE ENVIRONMENT FOR SPACE GOODS AND SERVICES, I.E., ASSUME THE ROLE AS THE GUARANTOR OF A LEVEL PLAYING FIELD FOR THE U.S. COMMERCIAL SPACE INDUSTRY.

THIS RECOMMENDATION LIKE OTHERS IS PREDICATED ON ACTION BY THE GOVERNMENT TO PROVIDE INSTITUTIONAL SUPPORT THROUGH:

1) THE DEVELOPMENT OF A STABLE AND ENDURING COMMITMENT BY BOTH THE PRESIDENT AND CONGRESS TO ENCOURAGE AND NURTURE COMMERCIAL SPACE DEVELOPMENT.

2) THE APPOINTMENT OF A CABINET LEVEL OFFICIAL AS THE FOCAL POINT FOR POLICY ADVOCACY.

3) THE ESTABLISHMENT OF A PERMANENT INDUSTRY COMMITTEE REPRESENTING A CROSS SECTION OF THE U.S. SPACE INDUSTRY TO ADVISE THE CABINET LEVEL OFFICIAL.

4) THE FORGING OF DEFINITIONS RELATED TO THE RESPONSIBILITIES OF THE VARIOUS GOVERNMENT AGENCIES AND HOW THEY WILL EXECUTE THEIR RESPONSIBILITIES CONCERNING SPACE BUSINESS.

THESE STEPS ARE THE BEDROCK FOR EFFECTIVE ECONOMIC DEVELOPMENT OF NEAR TERM AND LATENT COMMERCIAL SPACE VENTURES.

SINCE INSUFFICIENT TIME EXISTS TO TREAT IN DEPTH EACH OF THE RECOMMENDATIONS, I WOULD LIKE TO SPEAK ON ANOTHER OF THE RECOMMENDATIONS DEALING WITH THE GOVERNMENT IN ITS ROLE AS CUSTOMER. BUYING GOVERNMENT SPACE NEEDS AND SERVICES ON COMMERCIAL TERMS IS A POWERFUL WAY TO STIMULATE THE PRIVATE SECTOR TOWARD INNOVATIVE, COST-EFFECTIVE OFFERINGS TO SATISFY GOVERNMENT DEMANDS.

AS THE GOVERNMENT ACTS TO FULFILL THE EXISTING SPACE POLICY DICTUM TO PURCHASE COMMERCIALLY AVAILABLE SPACE SERVICES TO THE FULLEST EXTENT POSSIBLE, THE RESPONSE OF THE PRIVATE SECTOR WILL BE TO INCREASE INVESTMENT TO BE BETTER POSITIONED TO PARTICIPATE IN COMPETITIVE OFFERINGS.

THE U.S. GOVERNMENT HAS BEEN A GOOD CUSTOMER FOR COMMERCIAL COMMUNICATIONS SERVICES FOR YEARS AND IN THE STILL DEVELOPING AREAS OF COMMERCIAL ENDEAVOR REFERENCED IN THIS REPORT, IT WILL BE THE DOMINANT CUSTOMER FOR SOME TIME TO COME. WE BELIEVE THAT A NEW COMMITMENT AND SUBSEQUENT ACTION TO IMPLEMENT COMMERCIAL SPACE ACTIVITY WHEREVER POSSIBLE THROUGH THE CREATION OF COMMERCIALLY RELEVANT PROCUREMENT STANDARDS WHICH ADDRESS THE WHOLE SPECTRUM OF PROSPECTIVE COMMERCIAL SUPPLY, WILL MATERIALLY ENERGIZE THE PRIVATE SECTOR TO BROADEN ITS FINANCIAL COMMITMENT.

THE DISAPPOINTMENT AND CRITICAL COMMENTARY REGISTERED IN THE REPORT SPRINGS FROM THE IRONY THAT OUR ENVIABLE POSITION IN SPACE TECHNOLOGY IS NOT BEING UTILIZED AND FOCUSED TOWARD UTILITARIAN COMMERCIAL GOALS.

THE COMMITTEE SUPPORTS MANNED SPACE EFFORTS, BUT NOT TO THE DETRIMENT AND VIRTUAL EXCLUSION OF COMMERCIAL ECONOMIC SPACE DEVELOPMENT. WE BELIEVE THAT MORE ATTENTION MUST BE GIVEN TO OTHER SECTORS OF SPACE RESEARCH AND DEVELOPMENT.

TECHNOLOGY IS THE FUEL WHICH WILL KEEP OUR SPACE PROGRAM AND PRIMACY ROBUST. THE PARTNERSHIP AND PROPOSITIONS EXPOUNDED IN THE COMMITTEE'S REPORT WILL PRODUCE THE KIND OF POSITIVE SOLUTIONS SOUGHT BY BOTH GOVERNMENT AND INDUSTRY.

THIS SUBCOMMITTEE KNOWS THAT SPACE IS A HIGH STAKES GAME--BETTER THAN MOST; BUT THE FACTS ARE IF THE U.S. IS TO MAINTAIN ITS LEADERSHIP AND REAP ITS REWARDS, IT WILL TAKE STABLE AND DURABLE GOVERNMENT ADVOCACY LEADERSHIP AND INVOLVEMENT IN COOPERATION WITH THE PRIVATE SECTOR TO ACHIEVE AGAIN WHAT THAT COMBINATION HAS ACCOMPLISHED SO OFTEN IN OUR PAST.

EXECUTIVE BIOGRAPHY

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CHARLES A. SCHMIDT
Vice President and General Manager
Astro-Space Division

September 1988

Charles A. Schmidt was appointed Vice President and General Manager, Astro-Space Division, in October 1986.

With headquarters in East Windsor, N.J., he is responsible for GE's space business encompassing facilities in East Windsor, N.J. and Valley Forge, Pa. He reports to John D. Rittenhouse, Executive Vice President, GE Aerospace.

Prior to his current position, Mr. Schmidt had served, since December 1985, as Group Vice President, Government Communications Systems, Camden, N.J. In that position, he was responsible for RCA's Communication and Information Systems Division and Government Volume Production, both located in Camden.

Earlier, Mr. Schmidt was Division Vice President and General Manager for the former RCA Astro-Electronics Division, East Windsor, N.J., a position he had held since 1981.

Mr. Schmidt played a key role in the formation of EOSAT, a joint endeavor of RCA and Hughes Aircraft, for the purpose of assuming operation and responsibility for the U.S. Government's Landsat program.

After joining RCA in 1950, Mr. Schmidt held a number of engineering and management positions at the Government Communications Systems operation before moving to Astro-Electronics Division in 1981. These include Business Manager for the Integrated Radio Room for the Trident Submarine; Program Manager of the Tenley/Seeley Communications Security Equipment Program, Manager of Test Engineering and Manufacturing, and Manager for the Navy's P-3C Aircraft Radio Programs.

Mr. Schmidt, born in Newark, N.J., and a lifetime resident of South Jersey, received a bachelor of science degree in electronic physics from LaSalle College in 1963. He is a 1980 graduate of the Harvard Business School's Advanced Management Program.

A 1951-55 U.S. Navy veteran, Mr. Schmidt is on the Board of Governors of the National Space Club and is a member of the LaSalle University Business College Advisory Board and Council of President's Associates.

He is also a Fellow of the American Institute of Aeronautics and Astronautics (AIAA), and is a member of the American Defense Preparedness Association (ADPA), the Air Force Association (AFA), the Association of the U.S. Army (AUSA), the Armed Forces Communications and Electronics Association (AFCEA), and the Navy League of the United States. He is also Chairman of the Working Groups of the Commercial Space Advisory Committee of the Department of Commerce, and a member of the Commercial Space Transportation Committee of the Department of Transportation.

Mr. Schmidt and his wife, Gloria, live in Cherry Hill, N.J. They have three children.

Mr. NELSON. Thank you, Mr. Schmidt.

Members of the Committee, questions or comments.

Mr. Volkmer.

Mr. VOLKMER. Yes, I have several questions.

Jim, I want to join with the gentleman from California, Mr. Mineta, in commending you for the job that you are doing.

I have several questions for you, and also I have a question of Dr. Bugg.

In the first place in the utilization area, and I'm sure West Watkins is still quite interested in that, do you find more and more private companies and individuals in the private sector now coming in and, as I understand your testimony, wanting to learn more about space technology and the ability to transfer; is that correct?

Mr. ROSE. Yes, sir.

Mr. VOLKMER. With that, you had a list up there on the wall of a lot of flights that are going to take place up to around 1993 I believe it was. How many of those are over more than a 6 or 7 day duration need?

Mr. ROSE. Most of those that are identified there would probably be satisfied, Mr. Volkmer, in up to 16 days because you would target those things that you can fly that you would work on that you know you can complete in that time frame. I think Dr. Bugg might want to comment.

Mr. VOLKMER. Well, if he wants to join in, he can join in on this.

Mr. ROSE. There is no question that there are protein crystals that will take and could take as much as 30 days I guess, Charlie, or longer that represents a fairly large number, but by the same token there are a lot of crystals that you can work with that can be done in a week or 10 days.

Why don't you elaborate, Charlie, you're an expert.

Dr. BUGG. If you take all the hundreds that have been crystallized on the ground, about 90 percent of those can be crystallized in less than 3 weeks. There is a small percentage that it would take more than three weeks. But if we were able to fry up to 21 days, that would take care of most of the demands.

Right now what we are having to do is select samples that crystallize in less than a week because that's what we have with the Shuttle missions. The November Shuttle flight, the November 1989, which I believe is STS-32, will be a 10-day mission, and 10 days let's us start beginning to do experiments at lower temperatures, which there is a considerable demand for, but when you go to low temperature the process is slowed down so that it takes more than a week to be able to do that. It would be great to have 21 days.

Mr. VOLKMER. If we go to an EDL say to 16 days next and then eventually to 21, that pretty well takes care of most of your concerns then?

Dr. BUGG. Yes, most of them. There are still certain things that would take more than three weeks, but that's right, 21 days would encompass a very big percentage of the things that people are wanting to fly right now.

Mr. VOLKMER. The reason is that I have just been reviewing briefly the Academy's comments, the Committee on the CDSF, and I suppose it would be better—you haven't had an opportunity to review that, have you, either one of you?

Mr. **Rose**. No.

Dr. **Bugg**. No. I saw something in the Wall Street Journal, and that's about as lengthy as I have seen it.

Mr. **Volkmer**. I think in all fairness, Mr. Chairman, if we could hold the record open and give them an opportunity, 10 days or two weeks to review it, and then give us their written comments, if they would, on this.

Mr. **Nelson**. Without objection, and we will also be looking for additional comment on the Academy's. They have panned the CDSF, as you know, pretty well. So we want to give everybody an ample opportunity to talk about it.

[The comments to be submitted for the record follow:]

UAB
The University of Alabama at Birmingham
Center for Macromolecular Crystallography
205/934-5329

April 25, 1989

MEMORANDUM

TO: Congressman Bill Nelson & Members of the House of Representatives Subcommittee on Space Science and Applications

FROM: Charlie Bugg, Director, Center for Macromolecular Crystallography, University of Alabama at Birmingham

SUBJECT: National Research Council Sponsored "Report of the Committee on a Commercially Developed Space Facility"

Dear Chairman Nelson and Distinguished Members of the Subcommittee:

When I testified before your subcommittee on April 11, 1989, I had not examined the report on the CDSF. I agreed to provide you with my comments once I had an opportunity to examine this report.

Most of my comments are related to protein crystal growth, since that is the major focus of the CCDS in Birmingham, and it is the area of microgravity research in which I have all of my experience. However, I have no reason to believe that protein crystal growth is fundamentally any different from most other applications of microgravity processing.

Protein crystal growth is an experimental science. The molecular processes involved in forming protein crystals are far too complicated to permit detailed analysis at the present time by theoretical, nonexperimental approaches. As I stated in my previous testimony, the rate of progress in advancing microgravity protein crystal growth will be dependent upon our ability to access space for performing experiments. There are definite advantages to the space shuttle for certain types of experiments, and I believe that the Space Station will be invaluable in the future. However, I believe that a strong case can also be made for the potential advantages of free-flyers.

I am not qualified to address the detailed merits or cost considerations for the Commercially Developed Space Facility. Like other proposed free-flyers, it will provide a low-g environment that is considerably quieter than the environment available on the space shuttle. Free-flyers should also be capable of providing g-levels well below those that will be routinely available on the space station.

All of our experiments in protein crystal growth to date have been performed in the mid-deck of the space shuttle. Since these experiments occur over periods of several days, they generally are exposed to a number of disturbances that cause accelerations well beyond the "average" g level in the neighborhood of 10^{-3} g. These disturbances include orbital maneuvers, exercise regimens and the many accelerations that are unavoidable when several people are working in a volume the size of the middeck. Despite these disturbances, and a relatively high ambient g level, the results from our recent experiments demonstrate that the low gravity environment on the space shuttle allows us to grow crystals that are considerably better ordered than those obtainable on earth.

We do not know what additional benefits would be realized by performing these experiments in a quieter environment with g levels in the region 10^{-5}-10^{-6} g. Theoretical studies suggest that lower g levels should be better, but we really do not know what to expect. It is unlikely that we will know until we perform the experiments. Therefore, I am quite interested in having the ability, as soon as possible, to perform protein crystal growth experiments on a free-flyer.

A number of different options for free-flyers have been proposed. In fact, my European colleagues connected with the European Space Agency will have access to Eureca in 1991. This free-flyer will include a series of protein crystal growth experiments, and I am looking forward to seeing their results. I would prefer to have our science team affiliated with the Center for Macromolecular Crystallography perform these experiments ourselves, and I would like to see it done before 1991. However, the Europeans have designed a superb facility in Eureca, and I am sure that their experiments in protein crystal growth using Eureca will be quite informative.

I feel that we could automate our protein crystal growth procedures that have been developed using human intervention on the space shuttle. As discussed in the report of the NRC committee that examined the CDSF, robotics and telescience are still in developmental stages; however, the current technology clearly permits simple auotmation. The European Space Agency is planning to automate the protein crystal growth operations on Eureca, and their automation schemes look very reasonable to me. I do not feel that lack of sophisticated automation technology is a limiting consideration in the decision to develop a free-flyer for the U.S. Microgravity Program.

Assuming that human intervention in experiments will be desirable, this would seem to argue in favor of the CDSF versus other concepts for free-flyers. The protein crystal growth experiments that we are currently performing using the space shuttle primarily require human intervention at the activation and deactivation stages. If I understand the concept of the CDSF correctly, the facility would permit human intervention periodically, during the man tended mode using the space shuttle. Thus experiments that require human intervention for activation, but long-term quite environments for operation, would be well served by a free-flyer like the CDSF. In fact, I can see no real problem in quickly adapting our current shuttle hardware for protein crystal growth to operate effectively with a human tended, free flying facility like the CDSF.

As I mentioned earlier, I am not qualified to address the financial arguments for and against the Commercially Developed Space Facility. As I stated in my previous testimony, I feel that access to space is absolutely essential in order to develop new applications of the microgravity environment. Free-flyers clearly offer advantages for long duration experiments that require very quiet, low-g conditions.

Thank you very much for the opportunity to provide my additional input to your subcommittee.

Sincerely,

Charles E. Bugg

Charles E. Bugg
Director, Center for
Macromolecular Crystallography

CEB/mal

cc: Mr. James Rose

[illegible]

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May 3, 1989

Congressman Bill Nelson
Chairman
Subcommittee on Space Science & Applications
Suite 2321
Rayburn House Office Building
Washington, D.C. 20515

Dear Congressman Nelson:

During a recent hearing of your subcommittee on April 11, 1989, in which I was a participant, a request was made for input and commentary on a just-released "Report of the Committee on a Commercially Developed Space Facility" (CDSF) sponsored by the National Research Council (NRC) at the request of James C. Fletcher, NASA Administrator. I have completed my review of the report and, with your kind indulgence, have the following comments to render. It should be noted that I also gave testimony to this NRC committee on two different occasions--one with Centers for the Commercial Development of Space (CCDS) Directors and other NASA Code C officials, and the second with a private sector witness from Amoco Chemical Company. I am also well acquainted with several members of the committee authoring this report and their work in the space program.

The NRC established committee is to be commended for covering a large number of people in a short period of time to address the CDSF issue. Based on my knowledge of the individuals selected to appear before the committee, the group was indeed representative of all interests concerned with the establishment of the facility (CDSF). The committee report, however, lacks the breadth of understanding that I would have expected in an activity of this sort. Whether the CDSF ever gets built or not is secondary to the implications that space processing, indeed space research of the most fundamental nature, takes decades of ground study, and a parallel number of years and millions of dollars to develop space-qualified hardware. This implication, is unfortunate. It robs us of our creativity (i.e., new ways), it relegates us to basing future actions on history (i.e., it worked this way before), and finally, we seem to be drowning in our own quest for perfection. Whether we like it or not, we (the U.S.) are in a race with many other nations of the world. The race is not only for a large stake in low earth orbit (LEO) and beyond, it is a race for products and processes that will affect the world's quality of life. Someone will capitalize on that marketplace--I hope the "someone" is the United States.

There are two key words that I would like to address briefly in the context of the subject NRC report. They are: (1) Science, and (2) Time.

(1) Science. Throughout the report, references are made (p. 1--bottom, p. 18--2nd last para., p. 19--2nd para., p 20--#1 & #2) regarding the scientific inadequacy of the Office of Commercial Programs (OCP) flight opportunities.

The wording in these cited paragraphs is unfortunate. The implication is that we "hitch it up" and fly it. What is missed is that there are a large number of Corporate Research Centers devoting their time, talent, and facilities toward the OCP objectives; and toward specific projects that are well thought out, investigated thoroughly on the ground, and for which space hardware is being economically developed. What better cast of players could be found that can be scientifically sound and economical at the same time.

(2) Time. Also, throughout the report reference is made (p. 2--top, p. 10--5th para., p. 12--2nd para., p.20--#1) to the long periods of time required to perform satisfactory space science work. Phrases like "...no evidence to suggest....space manufacturing in the next five to ten years"; "...exhaustive experimentation on Earth must precede experimentation in space."; "...it is not unusual for individual researchers to devote a decade to designing the hardware...".

In both of the above points, the message is that it is going to take a lot more work and a lot more time to do anything significant in space, commercial or otherwise. While I can be somewhat sympathetic to that point-of-view, I believe we all have the responsibility to speed that process along. Our position in the world marketplace will require that we do. Furthermore, I believe OCP has already demonstrated sound scientific and hardware development movement that was unanticipated at the start of the CCDS program initiative. As mentioned, our corporate scientists are enabling sound scientific work to occur and a much more streamlined and effective hardware development scenario is underway.

As I discussed in my recent testimony before your subcommittee, one of our major concerns is the availability of flight opportunities. The CDSF is one possibility that does not now exist. I believe further opportunities will be needed prior to Space Station and, if something should delay the Station (technical or otherwise), I am afraid many commercial payloads would be left waiting.

Please accept my thanks for the opportunity to present my review comments candidly. The report contains many positive elements and I am especially gratified that the committee concluded that "the promise of in-space research and applications activity for scientific and commercial benefit is great".

Sincerely,

Frank J. Jelinek

Frank J. Jelinek
Director
Advanced Materials CCDS
Battelle
Columbus, Ohio 43201

cc: Mr. James Rose
Assistant Administrator
Office of Commercial Programs (Code C)
NASA HQ
Washington, D.C. 20546

Mr. **Jelinek**. Mr. Chairman, may I make a comment on Mr. Volkmer's——

Mr. **Volkmer**. On my point, yes.

Mr. **Jelinek**. What Charlie is talking about, and in our center we have the same problem. What we are talking about is hydrothermal crystal growth, and in hydrothermal crystal growth there are two parameters that affect the speed. One is the temperature and the other is the resulting pressure. So the problem that we run into when we talk about zeolite catalysis or the growth of zeolite crystals, which is significantly important commercially, we're talking about essentially the same process.

When we do this in a short flight, 3 to 7 days let's say, we have to increase the pressures dramatically because we have to increase the temperature. So we are running into tremendous extra costs as a result of developing hardware that is triply contained and can handle the pressures. NASA's safety people have extreme difficulties when we start talking three, four or five and even a thousand psi materials. If we had 21 days or if we had 30 days with zeolite catalysis we could do it just barely above the boiling point of water and with pressures of slightly above say one atmosphere.

So the same major commercial technology could be developed over a longer time with less safety considerations.

Mr. **Volkmer**. All right. Along that line and reviewing what this says, are you able to do those experiments on an automated basis, or are we going to have to have somebody there attending that experiment for that full 30 days?

Dr. **Bugg**. Well, the way things like this usually progress, and it's certainly happening right now with protein crystal growth, those initial experiments having a person running the experiments was extremely important. It allowed us to learn things that we couldn't pre-anticipate and to run experiments that would have been so difficult to automate up front that it really would have made the science very difficult.

But then once all of that is done, for instance, the system that we have right now that has been developed due to the fact that we had those first four flights with people doing lots of different experiments, we are now at a point where the current piece of hardware we could automate and we are in the process of trying to automate it where it could be done without a person being involved.

But that's just one step. That one technique, that one piece of hardware is just the beginning. We want to try to develop entirely new ways of doing this and to advance entirely new technologies, and during that research and development stage it's very difficult many times to conceive of how you can run ideal experiments without a person there, a person that can react and can observe things that may not be anticipated.

So I see a combination, at least in my field, developing as we develop a piece of technology using people up front to help us do the research and development and finally end up with a piece of equipment that works pretty well, and where we know what all the uncertainties are and have solved most of those, we'll probably able to then automate that piece of equipment, and meanwhile we'll be working on the next stage, the next way of doing it where people will be critical.

Mr. **Volkmer**. Right, and as you get into different types of crystals, et cetera, you've got to go through that learning curve basically all over again, do you not?

Dr. **Bugg**. Right, and we are working on entirely new ways of doing this that are different from the ways we do it on the ground right now.

The thing that amazed me when we first started running these experiments is how difficult it is to anticipate what is going to happen when you get rid of gravity. You know, we have models and we are able to do a lot of predictions on all this, but it's still an area where we know so little about what is involved. In order to automate, you have to be able to anticipate, and until we run a number of experiments in many cases, we don't have that ability.

The Space Station is going to really be the way to do this right where we can run real experiments. A person can run an experiment, we analyze the results, see what happens, turn around and redesign the experiment and rerun it without wasting 6, 7, or 8 months to be able to go back and access it again.

But I can see a whole level of different ways of doing this, and a piece of technology develops to the useful stage, and our current equipment is very close to that point because of the fact that we had six flight opportunities to get it there, we'll be able to soon automate the way we're doing it right now while we are working on manned experiments that are new generation experiments that require people in the loop.

Mr. **Volkmer**. And there is no reason that you can't send automated experiments on the Shuttle just as well as you can send manned experiments. In other words, if you have like more room like in the SPACEHAB, right?

Dr. **Bugg**. Yes.

Mr. **Volkmer**. We are ongoing with the SPACEHAB, right?

Mr. **Rose**. Yes. Let me add to what he had to say because it goes back to the electrophoresis program.

Mr. **Volkmer**. I was going to ask you about that. That was man tended all the time.

Mr. **Rose**. Well, it was man tended just for the same purpose he said. While we were in the research and development mode we had our own astronaut. In fact, I was negotiating with Charlie Schmidt down here for an unmanned free flyer to allow us to produce commercial quantities on a year round basis and visited by the Shuttle on a 4 to 6-month time interval.

So I think the concept is once you know what it is you want to do and you've got the technology in hand, then you can automate, and you can prepare to operate in those types of environments, but it's very difficult. I've seen an automated research laboratory on the ground. So I don't know how to do that.

Mr. **Volkmer**. My comment, as you remember, Jim, is my concerns about the CDSF last year, the need for it, et cetera. That gets me back to this, as to whether or not we are going to need something additional before we get to the Space Station, which I understand now is going to be fully operational, if we get it fully funded, by 1998. We're looking at 1998 now.

In between whether we will need something else, the question is if we are able to build a free flyer that we can use automated systems on, the question is do we have to go as far as a CDSF or can we use something like Fairchild or somebody else at one time had proposed?

Mr. **Rose**. I think that is all quite practical. I guess my approach in where I envision we are going to go as we develop these technologies, in these product related areas we are going to find, and the private sector who is developing these things is going to demand more cost effective transportation, and that in turn could very well be unmanned ELVs to get you up there, and either using Shuttles to come down or either to use a reentry system to come down if you can.

I don't think protein crystals, like the high G reentry, it might require them to be brought back on a Shuttle, but there are certain things you could probably automate and could probably do.

So I really believe that as we develop these markets and products there are a lot of opportunities for the commercial world to develop cost effective free flyers, launch vehicles and other things are going to emerge. It's just that we've got to develop the markets, and I think everybody will agree with that.

Mr. **Volkmer**. There could be a possibility of developing a free flyer that could be brought back in the Shuttle and taken out.

Mr. **Rose**. Oh, yes.

Mr. **Volkmer**. Or you could develop one where it's tended up there and stuff taken out.

Mr. **Rose**. The Shuttle is quite versatile. Remember, they brought two or three satellites down they had no intention of bringing down.

Mr. **Volkmer**. Right.

Mr. **Rose**. They brought them back. You find ways to cradle them and put them in the bay and bring them home.

Mr. **Volkmer**. When will be utilizing the SPACEHAB?

Mr. **Rose**. SPACEHAB, we are in the process right now, Mr. Volkmer, of finalizing. You say that list I gave you payloads being developed by year. We are trying to assess how many of these are really going to make it in the early part of the year so that you can plan the process of how we are going to accommodate all of the payloads that we are now showing under development, and within the next several months we should have a reasonably good handle on what we need in 1991. The first flight of SPACEHAB is in I think November of 1991.

Mr. **Volkmer**. Is that actually manifested now?

Mr. **Rose**. It is manifested, yes. SPACEHAB is now manifested officially five times, and there will be a sixth when the manifest reaches that time in the system. So the SPACEHAB will fly. If we need space to accommodate these payloads, I intend to move forward aggressively with our new Administrator and confirm that we will need appropriated funds or a barter arrangement with them to be able to accommodate it.

Mr. **Volkmer**. In other words, you've got a manifest date now of November of 1991.

Mr. **Rose**. That's correct.

Mr. **Volkmer**. Now, Dr. Bugg, does that help you in preparing your experiments as far as getting on a flight?

Dr. **Bugg**. The real surge in demand is going to begin I guess next year from the commercial standpoint, or the next year or two. In protein crystal growth we had the very fortunate situation of being able to fly four times in 1985 and 1986 and to have the post-Challenger period to develop a piece of hardware that is ready to go. So consequently we have been able to fly on a fairly regular basis and have a fairly aggressive flight program planned.

But meanwhile the other CCDS's are getting up to the same stage. When they all get to the stage that our center is at right now, there is going to be a tremendous demand for space on the Shuttle. It's totally different from what we have right now. I mean right now there aren't that many pieces of equipment ready to go. So consequently we have been able to have lots of flight opportunities, but by 1991 we are going to need lots of capacity in order to be able to get the sort of regular flight opportunities that we clearly need in order to keep this program going.

Mr. **Volkmer**. How far in advance were you given as far as Shuttle flights in the past as far as getting your commercial experiments on board?

Dr. **Bugg**. In '85 and '86 if they gave us two or three months' notice, we were ready to go because we had a fairly simple system. We just during the past few weeks have made the decision to go in December of '89. We can go at this stage with just a few months' notice because we have a piece of equipment that is debugged pretty well and working, and we have a large number of coinvestigators that are now in the program and that are sitting on go waiting to provide samples.

We could fly once every 2 or 3 months right now and in every flight be able to do some very exciting things. But all we need is just a few months' advance notice right now to get ready because our equipment is such that we can turn it around pretty quickly.

Mr. **Volkmer**. Mr. Jelinek, do you have any comments you wish to make on time frame?

Mr. **Jelinek**. Well, I agree with Dr. Bugg. We have two pieces of equipment that are currently under design and construction. So we are going to need much more time than two or three months to turn things around.

The anticipation on the hydrothermal crystal growth hardware is to have it completed by the end of 1991. That is a very complex piece of hardware. After that is finished, and after that hardware is built, then we'll be in the same boat that Dr. Bugg is. We will be able to fly every three months.

Similarly, we have just acquired, or Code C has just acquired from Code E who have no longer any use for it, the Monodispersed Latex Reactor. We have asked Code C if we could take it under our custodial care in our center and refurbish it. It needs a new electronics package. We plan to have that completed by the spring of 1990, that's a year from now, after which it will be ready to fly numerous times as often as we can get space to fly it.

So assume for that piece of hardware, let's say late 1990, we are ready to go on a regular basis, and for the more complex piece of hardware currently on the board it will be another year later. But in any case, we are talking in the '91 and early '92 time frame before we could fly every three months.

Mr. VOLKMER. Do you anticipate utilization of the SPACEHAB?

Mr. JELINEK. Yes, sir.

Mr. VOLKMER. What about the other centers, Jim?

Mr. ROSE. The other centers for the most part, the list that we showed you, they are compatible. There will be some hardware that will require payload bay accommodations because of the power that they need and the size that will fit in a rack or something. The SPACEHAB is almost identical to the Mid-Deck. So what flies in the Mid-Deck can fly in SPACEHAB and vice versa.

We have a certain percent of available space allotted to us in the Mid-Deck, and right now I guess our official allotment is 31 percent and we are averaging this year over 40 or more. I think we are the biggest user by far because we are ready to fly and because we've got Charlie's equipment and some others, and we are taking advantage of those opportunities.

So when we say will you fly in SPACEHAB, most of these people will fly in SPACEHAB or Mid-Deck where you need pressurized volume containment. As I said before, we rack up all the year's requirements and we know more precisely how much space is going to be available in Mid-Deck and others we can arrange our manifest to accommodate that.

As I said earlier, we acquired Mr. Dick Ott, sitting behind here, who for 13 years was responsible for manifesting the Shuttle. So he knows the tricks and he knows when we need to do things in order to take advantage of any available space, and we are trying to do that. What I'm saying is that if we need more capacity, we will ask for it.

Mr. VOLKMER. The last question I have is how are we going to recover basically the cost on the SPACEHAB? I mean it's commercial space venture?

Mr. ROSE. The SPACEHAB was quoted a price for dedicated, well, not dedicated because it takes out about a quarter of the payload bay, but it was quoted the old pricing formula that——

Mr. VOLKMER. Are we using $110 million on it?

Mr. ROSE [continuing]. $110 million has been used for that, and they used a length calculation, and it's a pretty expensive thing. To use the SPACEHAB with that type of pricing, only governments can afford it.

Mr. VOLKMER. Are these centers going to get on?

Mr. ROSE. Well, the centers are going to get on, and that's what I mentioned earlier, I've got to come to you and say we can either barter with them and say NASA gets to use a part of that for letting you fly, or either we will ask for appropriated funds to lease enough space to fly our payloads because it is important that these people fly.

Mr. VOLKMER. In other words, without some type of arrangement, Dr. Jelinek and Dr. Bugg, you're not going to be able to fly on the SPACEHAB, are you? You don't have that kind of money, do you?

Dr. BUGG. Not $110 million.

Mr. VOLKMER. Well, you wouldn't go that much for a trip, you know, you're part of it. You're not going to take the whole thing, and the SPACEHAB only takes maybe, say, 20 or 25 percent. So you're looking at around $25 million for the SPACEHAB, and if you take up a fourth of that, you're talking about maybe $6 million. But where are you going to get $6 million?

Mr. ROSE. Nobody doing research will pay $6 million in the United States or the world, I can assure you.

Mr. VOLKMER. Or $5 million or anything else.

Mr. ROSE. Any of those.

Mr. VOLKMER. Thank you, Mr. Chairman.

Mr. NELSON. Thank you, Mr. Volkmer.

Mr. Johnston.

Mr. JOHNSTON. No questions.

Mr. NELSON. Mr. Rohrabacher.

Mr. ROHRABACHER. Just one question. A lot of what I've heard, and I'm sorry for being late. It seems we have three or four different meetings in exactly the same time, Mr. Chairman.

In the long run do you think we are going to be mining materials from the moon and bringing them back to earth? Is this something that is being thought about now?

Mr. ROSE. Yes. To put it simply, one of our CCDSs at the University of Wisconsin, which is one specializing in automation robotics, has also been exploring a little more of the advanced far out what do we do, how do you colonize, how do you grow food and how are you going to self-sustain. This is good technology because we are going to need it obviously and they see a commercial application downstream.

It so happens, as you have been reading in the paper, that people are getting quite interested in fusion reactions as a way of replacing all of our fission energy sources as well as the very dirty fission of fossil fuels. It so happens, and I'm not an expert by any means on this, but it's my understanding that it's well recognized that Helium 3 is the best possible fuel to use in fueling a fusion reaction because it doesn't give off any neutrons and therefore is very clean. Therefore, you can stand next to the reaction and it won't bother you from the standpoint of view of safety.

And after 30 years of operation the equipment would probably have no damage associated with it and you could dispose of what's in the reactor like you would hospital wastes.

The problem is that we don't have too much of it on this planet because of the electromagnetic field which blocks it from coming in from the sun. So somebody got the idea saying we brought a lot of moon rocks back and nobody has complained and they weren't worth very much, but when they were all examined they have high concentrations of Helium 3 on them.

It has been predicted that one Shuttle flight a year, I mean a payload bay full of 65,000 pounds, full of this material if it could be scooped out of the surface soil, which it's supposed to be abundant in, would fuel the United States for a year.

Now this has gone beyond just speculation. They have actually entered into discussions with the DOE and other agencies to begin to look at the potential of helium as a potential source of fuel, and if these new reactions make some sense, maybe that's a simpler way to do it than the high temperature methods that have not worked so far, but are making progress.

So to answer your question, it might be a very good reason one day to go back to the Moon.

Mr. ROHRABACHER. All right. I was just wondering about a lot of the commercial activities that we're talking about seem to be experimentation and not manufacturing or bringing back materials. When do you think we will get to a point, or at what time, is it the Space Station, is that the time we start manufacturing, or is it beyond the Space Station? Are we talking about 20 years from now when we get to a situation where it's more than just experimentation when we talk about commercialization of space?

Mr. ROSE. Let me take a crack at that, and then I'll turn it over to these gentlemen. I headed a program at McDonnel-Douglas that we were going to develop a pharmaceutical product and had developed a process to do that, and we had predicted a 10-year timeframe in order to carry it out, starting with technology on the ground, moving into flight technology or what I call applied technology, moving then into a development program, then moving into a pilot program to prove that you could scale up and then be in a position to begin to tackle a market, an initial market and then grow that market. This we thought would be a minimum of a 10-year time frame.

We had reached the point of pilot plant demonstration when Challenger went down. We had the factory built and we had reached that point, but we were so far ahead of anybody else. Most all the other work at this point had been either on ground research or was in the applied technology stage. That's where we are today, but it's got to start there, and it's going to take some years to bring it about. But I think with the involvement, and let me go back.

When we were playing in this in the late 1970's and early 1980's there were just a few companies involved, a few companies. Now we have shown you that we think we are opening a lot of interest through these centers for a wide spectrum of industry interest. Some of that interest is going to pay off, there is no question.

Mr. DONLEY. Maybe I could comment on that, Mr. Rohrabacher.

Mr. ROHRABACHER. Yes, sir.

Mr. DONLEY. I think we have to recognize that these technologies are so new that they are indeed going to be long term, and 10 years is at least that long I think in many of them. I think that's the reason that we have to have a private sector/public sector participation, because rightly or wrongly the finance system of the United States does not permit corporate management to go for long-term capital investments.

If you in a company like ours put in large amounts of money for long-term capital investments, your current earnings will be depressed and before you ever get to the top of the mountain it will be taken over by some raider, and that doesn't happen in other industrial countries. There the government and the private sector participate in the commitment of public funds to enhance the long-term development of new technology. If we are, as I said earlier, going to remain competitive in world markets, we're going to have to adopt practices of that kind.

Mr. ROHRABACHER. One question relates to your first answer in terms of perhaps bringing things back from the moon. Are we going to reach a time period when it becomes profitable for us to send these like toxic wastes and nuclear wastes up there? Is that going to be our garbage put up there?

Mr. ROSE. That scares people I think to think about doing something like that. I don't think there is any serious discussion on that, but that's why you eventually want to get to something like Helium 3, if it really works, so you don't have any waste of any consequence to dispose.

I think we do have a waste problem in this country, and it's another technology of looking at other ways to maybe take care of it, but I have not heard anybody seriously talking about using it and dumping it in space.

Mr. ROHRABACHER. Coming from California, we have a lot of water underneath of Orange County, and the very worst thing that could happen to us is if in trying to get rid of our toxic wastes or anything like that, that groundwater would become polluted with some kind of radioactive substance or whatever. It seems to me it would be more worthwhile to shoot it up there than to put it in the ground where it might end up in the water.

Mr. SCHMIDT. Mr. Rohrabacher, this particular topic of the exploitation of materials and development of materials and processes was the subject of a lot of committee discussion, and one of the companies that was mentioned here today, who is one of the primary users so far of space microgravity research, pointed out that much of what they do and attempt to do in microgravity is to find out what growing a perfect crystal really will do to a material and its structure and then see if they can do it on earth because at the present time nobody as far as I know has figured out how to do any manufacturing in space at some cost benefit ratio.

Mr. ROHRABACHER. I see. Well, thank you very much, unless anyone else has anything else to say about that.

Thank you, Mr. Chairman.

Mr. VOLKMER. Does the gentleman from Florida have any questions?

Mr. JOHNSTON. No, sir.

Mr. VOLKMER. All right. I have several more questions. I would like to go back to Jim just for a minute.

You mentioned the JEA's that we've had around for a while, and of course I'm sure that we didn't have any sign-ups between 1986 and late 1988. How many sign-ups have we had since then?

Mr. ROSE. We have not had a specific sign-up of a JEA per se. We have signed some SSDA agreements, and we have also had some memorandums of understanding arrangements. There hasn't really been a new partner that has reached the point that he wants to move aggressively forward.

Now Genentech it looks like is coming aboard. We have eight other companies that are in negotiations now. One is a major oil company who has a proprietary sensor that he believes they can locate oil reserves through seepage arrangements with this particular sensor. He is anxious to begin the process of flying and in testing this instrument and determining its viability. So we do have some very interesting ones, and most of these are not aerospace companies.

So I think with the Shuttle back in flight that there is a definite stimulation of interest by the private sector and we are getting much more, let's say, communication set up with companies that are now looking.

Now a lot of companies, who might have gone into JEAs because there was no other mechanism, are more comfortable in starting in a CCDS, and I think we have one in particular in Battelle who will fly one flight in a CCDS to determine the suitability of his theory. If he is right, this company will move directly into building their own hardware and wanting to go into a joint endeavor.

Mr. VOLKMER. In other words, they are looking now also at going to one of the centers and helping to fund a program along with the center, to develop a flight and experiment and get that on board and if it proves out, then they will come back and look for a joint endeavor.

Mr. ROSE. We want the CCDS's to spawn joint endeavors and joint endeavors hopefully will spawn commercial activities.

Mr. VOLKMER. What about flights by companies basically where they just buy a part of a payload without a joint endeavor, do we have any of that?

Mr. ROSE. Yes, and even those companies need some type of assistance. In other words, the joint endeavor is not available for companies who have something to sell and are in a position to begin to have a revenue stream. But there are a lot of companies that are start-up companies and a new business who cannot afford to pay the up front costs of transportation. So what we have is what we call an SSDA, a space systems development agreement, which will allow deferral of the launch costs until a suitable time, that is negotiate it with these people on a pay-back scheme. So it gives them the opportunity to get into a cash flow position and let them get economically hopefully stable before they will pay back for the launch services.

Mr. VOLKMER. So do you envision then that we will still continue to use JEA's for some time in the future?

Mr. ROSE. Yes, I don't think there is any question. I think we are going to help stimulate the growth of markets and new products that will also then stimulate transportation and infrastructure. We've got to provide access to space to help these people develop those technologies, and then as they spin off, they can go in a variety of ways with various forms of transportation which will be a healthy and vigorous growing way to go.

Mr. VOLKMER. Let's assume that one of these experiments does pay off and the company feels that the product is mature enough and the way they do it is mature enough that they can go into a commercial venture. Now do you have the ability to transition from either a JEA or SSDA to strictly commercial without any difficulty?

Mr. ROSE. That's no problem. The problem is going to be, if things can be done on a Shuttle until we get a Space Station or until we can get commercial facilities in space, is to not compete with commercial carriers like SPACEHAB or others by using Mid-Deck accommodations at different points. So there are going to be some things we have to work out to make sure that there again we have a level playing field within the capabilities of space that we have available that could be used by a paying commercial customer.

Mr. VOLKMER. Mr. Donley, I have a couple of questions for you.

Will your committee be issuing a set of recommendations regarding NASA's commercial space mission?

Mr. DONLEY. Yes, sir. We expect to have our report ready to issue by the end of May, and it will include recommendations.

Mr. VOLKMER. Have you gotten far enough into that report so you can give us some idea of some of the highlights of that, or would you rather wait until the report is finalized?

Mr. DONLEY. Well, I can't speak for the whole committee because we haven't concurred yet, but certainly we will concur that it's very necessary to have better coordination among all the agencies in Government involved with the space arena, and the second kind of overarching view that we will express is it's necessary to create this kind of atmosphere in Government that invites and encourages the private sector to have confidence when they come into relationships with the Government that they will go on on a continuous basis.

That need not surprise us actually. When you think about the history of NASA, President Kennedy said go to the moon and bring the men back in a year, and the United States provided the money to do that, and of course they achieved the glorious record that we know about.

But that doesn't encompass any kind of expertise in a far more I think complex world private sector of how one transfers technology, how one attracts private capital and how one develops technologies that are marketable in a commercial world, and that kind of thought process has to be infused, in my clear judgment, in a much greater degree into NASA than it has been now, and I think it has to start with this Congress, it has to start with the Bush administration and all the way down.

We have to come to a conviction, we the people of the United States have to come to a conviction that there is a payoff for the country if we can create an atmosphere which is attractive to the private sector to come into these partnerships.

Mr. VOLKMER. Now the Commercial Space Advisory Council is set up. When you make your report, are you all going to just disband and forget it, or do you think you'll continue to meet?

Mr. DONLEY. We have been organized as a permanent subcommittee of the NASA Advisory Council. However, you have to bear in mind that the member of this committee are CEOs of important corporations and CEOs of important universities, and whether once we transition from a target of preparing a report and submitting it in the spring of 1989 into a permanent ongoing committee that would require a commitment of time on the part of those extremely busy individuals permanently, I don't know whether we could make that transition or not. We'll lose some of the members.

But if we had a strong indication from the administration and from your Committee and the Congress overall that this contribution was going to affect things in the United States, then I think we could get these particular members by and large to stay on board and commit their future time.

Mr. VOLKMER. You have mentioned, just to go back to another item, you have mentioned the need for, and I think everybody agrees with you on this, reliable competitively priced access to space in order for us to have space commercial programs and have economic policy for the space commercial sector, but how do we do that? How do we guarantee that? We have seen what happened with the Challenger and we have seen ups and downs in the expendable launch vehicles and their limitations. How do we do that?

Mr. DONLEY. Well, I think, Mr. Volkmer, that the Space Station, if we get it up there, I perceive it as a steady, reliable platform on which we can conduct this work. Now the question comes into the competitive cost, and there we have to, like a business person running a private sector business, look at what their competitors are doing. And many times in business if you think you don't have the technology to be competitive, you've got to get out. But if you believe you have the technology which is competitive in the long run, then you may have subsidize in your company for an interim period until you get adequate market share to be competitive with your world competitors, and I think the United States Government is going to have to look at the space activities in that light.

Mr. VOLKMER. In other words, we are going to have to look at whether or not we feel that we can afford it also or not afford it, either way.

Mr. DONLEY. It's conceivable. I think it would be an error for our country, but it's conceivable that we as a nation would decide we can't compete in the space field, that it's too costly and we have too many other demands on our budget.

The alternative, which I would advocate, would be that we say the long-term payoff is intrinsically great for this country and therefore we must watch what the Soviets are going and what the other people around the world are doing and price our services to the private sector at a level that will enable us to compete until the payoff begins to be realized.

Mr. VOLKMER. Now do you believe that the 30 percent share of NASA flight facilities, that is actually the Shuttle uses that is currently allocated to industry uses is sufficient to prepare us for a permanent manned operation in space say by 1998 when we are going to be on the Space Station?

Mr. DONLEY. I'm not well informed on that specific subject, Mr. Volkmer, but my understanding is that 30 percent is not allocated, but that 30 percent after other high priority missions is allocated, and since we in industry don't know exactly how much of the total capacity those other high priority missions will take up, that it may be something less than 30 percent, and I think that's an area of concern that needs clarification.

Mr. VOLKMER. All right. I agree that we probably need to clarify that.

Yes, Jim.

Mr. ROSE. It's 30 percent of secondary payload space, which is primarily the nooks and crannies after primary payloads have been manifested and the Mid-Deck space that is available for use for experiments. That's basically the makeup of that 30 percent.

If we have an aggressive program, which I believe within the last 6 to 9 months we are beginning to see emerge, and if we are going to accommodate these people, then we had better start thinking about how we are going to do it because this is where your industries are going to come from in the future, and unless they get into space on a timely basis, they can't wait a year or two after they get their industrial partners involved with them. We are going to have to get them into space on a timely basis, and I think we are going to need additional capabilities on different carriers.

Mr. VOLKMER. ELV's.

Mr. ROSE. Some of them might be ELV sounding rockets. We have had a very fine success with a totally private venture between one of our centers and the SSI Corporation who competed and won it on a private service basis, and that's a step in the right direction for commercialization I think.

Mr. VOLKMER. Mr. Schmidt, can you clarify the status of the report of the Commercial Space Advisory Committee to the former Secretary of Commerce?

Mr. SCHMIDT. Well, the status is that it's issued, it's final, and it has been final since January 19th I guess.

Mr. VOLKMER. When was the release of that, the public release?

Mr. SCHMIDT. On January 19th we delivered it. It's a strange date to deliver it as everybody was leaving, but that was the best we could do in terms of getting it done. It took a lot of effort. It's the final report with all the words and music, but we didn't go to print into this volume until probably three weeks later and how we are distributing this. But right now we have the world's supply of these reports.

Mr. VOLKMER. And it has been formally released now to the public, and it's available to the public.

Mr. SCHMIDT. Yes, it has been.

Mr. VOLKMER. Do we still have a Commercial Space Advisory Committee under our new Secretary Mosburger?

Mr. SCHMIDT. No. The purpose of the committee was to analyze and write a report on their findings on what would enhance commercial space development.

Mr. DONLEY. Mr. Volkmer, I might make one other comment in response to your question about the Commercial Programs Advisory Committee's future as well, if you wish.

I heard Mr. Albrecht of the National Space Council say earlier this week that they were going to have an Advisory Committee to give advice to them and, among other things, in the commercial field. So I think that we are at a turning point in the history of the country, and I think it's going to be hard to get very busy industry and academic executives to serve if they feel that they are just going to be one of a multiplicity of committees who are giving advice. But if we organize this in such a way that we decide where we want the advice, then I believe we can get top industrial and academic people to commit their time.

Mr. VOLKMER. Well, some of us feel that maybe we need some advisory to the Council, especially potential users of space so that the Council can be apprised and updated periodically on that, and also those who are let's say providers of space transportation and experimental work or whatever-have-you.

Mr. DONLEY. When we tried to put together our committee we set some criteria that we thought were important, and the two you mentioned were important. We thought we should have some people, a minority from the aerospace industry because they have such a degree of knowledge about these subjects, we should have small entrepreneurial high-tech companies so we can get their viewpoint, we should have large, established companies so we can get their viewpoint, the CEOs of these companies, we felt that we should have somebody from a venture capital background in Wall Street or elsewhere and we thought that we should have somebody from a conventional investment banking firm.

So that we drew up an array of the kind of skills that we thought could contribute to helping give advice to NASA about how to get over this private sector/public sector interface and get some real businesses that were running in the private sector.

Mr. **Volkmer**. Okay, thank you very much.

Mr. Schmidt, I haven't been able to read your report, but I have been informed by staff that your report recommends the appointment of a Cabinet level official as a focus point for commercial space policy advocacy.

Mr. **Schmidt**. Yes, that's true.

Mr. **Volkmer**. Who would that official be?

Mr. **Schmidt**. Well, that wasn't what we felt our role was, to define who that official was. We have great admiration for Mr. Rose and the work that he has done, but we feel that the commercial space activity in the mode that it's in right now is like putting a house pet in the same room with a 300-pound gorilla and assuming that the accommodations of each will be addressed by logic, and it just doesn't happen. And despite a lot of effort that they do, we don't think they have enough money, we don't think they have enough authority or priority in that whole range of business that is being done by NASA.

When I listened to Mr. Donley and some of the things that he said, I'm becoming convinced that, with some small exception, the results of their report are going to be very much similar to the results of our report because we think that the needs are obviously and universal and objective people will arrive to them.

What we suggested and toned it down a little bit was it's time to stop having study committees and start implementing some of their recommendations because there is an awful lot of similarity between any committee you put together. There are things that everybody focuses on and says this is what we need to do, and I think we need to do them.

Mr. **Volkmer**. In other words, would we have an advocacy office or official outside of NASA?

Mr. **Schmidt**. The Cabinet level was brought up because we felt he had a direct voice in the administration to the President, he had a budget and a certain kind of authority, maybe less independent of some of the administration budget operations that restrained many things, and therefore as an advocate for space he would be responsible for that budget, responsible for implementing Government policies, responsible for helping industry to get over the wickets and barriers of the four or five agencies, all of which have some stake and authority, in anything to do with space, and it makes it very complex for anybody that wants to get involved in a commercial way, and unless he has a tremendous fortitude to throw up their hands and walk away from it and say I'll wait until its more real.

Mr. **Volkmer**. Are we talking about a separate Cabinet position?

Mr. **Schmidt**. No, no, no.

Mr. **Volkmer**. Some existing Cabinet position.

Mr. **Schmidt**. Some existing Cabinet level.

Mr. **Volkmer**. Well, that's all right. I'm not going to comment on it, Mr. Schmidt. I can understand your reasoning why, but I'll be honest with you as one who has been around here now and I'm going on my 13th year, I think if you pick it outside of NASA you're going to create all kinds of H-E-double-Q up here.

Mr. **Schmidt**. Well, we would probably be happy then if the result was to put it in NASA and give it some priority.

Mr. **Volkmer**. Well, that's fine. That's basically what we have, and it's just a question of whether or not we've given it sufficient priority. That may be a valid criticism as to whether or not it has it.

Did you also look at the Office of Commercialization in Commerce on the ELVs——

Mr. **Schmidt**. No, that's in Transportation.

Mr. **Volkmer** [continiung]. In Transportation. It's hard to put it in Commerce, excuse me. I wanted to put it in Commerce, but it got beat, I remember that.

Mr. **Schmidt**. We considered that to be part of the maze that would-be commercial entrepreneurs have to plow their way through.

Mr. **Volkmer**. In other words, you just see that as part of all these agencies that are involved.

Mr. **Schmidt**. Right.

Mr. **Volkmer**. Let me ask the two Center Directors if they have any comments on basically what Mr. Schmidt has said as far as a sufficient emphasis on the commercialization factor from your viewpoint?

Mr. **Jelinek**. My only comment from my viewpoint is that there is not enough emphasis on the commercialization aspect of space up to now in my belief. I mentioned one little, small point perhaps on a viewgraph that said that NASA needs to cater to our private sector industry. They need to be educated. I think the CCDSs fills a part of that function.

From the standpoint of a separate entity and commenting on Mr. Schmidt's comment, is that a separate entity that would do that, a Cabinet position, for example, I believe it still has to come from NASA because the high-tech that NASA has developed belongs to NASA and synergy between an independent extraordinary, and by that I mean outside of the loop body, would seem to me to cause a tremendous amount of difficulty.

Mr. **Volkmer**. Dr. Bugg.

Dr. **Bugg**. The Office of Commercial Programs has been able to sort of crack the door a little bit for industry to come in, but it's not wide open by any means, and yet the number of companies that over the past three or four years have gotten involved in this program is amazing to me. And yet the level of priority that this program has, the way I see it, cash-wise if you look at the dollar level, is nowhere near matching the potential the program has. I mean these companies that are involved are the backbone of our economy and high technology is the future of this country.

I speak as someone that has a strong vested interest in technology, but I honestly believe it, and I think the program that NASA is sponsoring through the Office of Commercial Programs has been a tremendous success, especially when you look at the budget level and the priority that it has. I think the thing it needs is it certainly needs higher priority.

There are a lot of good ideas that Jim Rose and his colleagues have that they will never be able to afford within the current budget restrictions. But it's more than just money. I think there is a program here that has immense potential, it involves some of the major actors in the United States and is sort of regarded as a stepchild, or at least people outside of the program would have that view of it.

Mr. **Volkmer**. All right. I have one other question for Dr. Jelinek and Dr. Bugg.

Should the centers be expanded to include new areas of space research and technology and, if so, what areas would you recommend, and are they broad enough?

Mr. **Jelinek**. I suppose you could make an argument or make a case for taking some of the artificial robotics and things of that nature and break it down into smaller pieces, but at the moment I believe that we have the freedom within the CCDS structure, the 16 of us, to broaden our wings a little bit within a technology that seems to be emerging.

In other words, when we first started in our particular center we called ourselves the Advanced Materials Center, and that kind of covers everything. So we don't have any major difficulty in introducing superconductivity into our list of things that we would like to pursue. So I think for the most part at the moment, reserving judgment to be able to change later, at the moment I think they are broad enough.

Dr. **Bugg**. Well, certainly that list of topics covered by the centers, depending on how you interpret those fields, cover most of science basically, and there may be a need for additional individual centers, but I think the areas that the Office of Commercial Programs identified as being the general areas that need to be approached are fairly comprehensive.

If you move to something like life sciences, that's an awfully big area, and there may be a need in the not too distant future for additional CCDSs to focus on certain areas of the life sciences that seem to be especially promising.

I think the main thing is to make sure that there are adequate resources to keep the viable programs going that are going right now and to try to expand the resources to accommodate new CCDSs, not entirely new areas, but to strengthen those areas that needed even higher priority.

Mr. **Volkmer**. Do we have any center focusing at all on communication?

Mr. **Rose**. No. That is an area that I think we can expand into and I think we need to. I think we need an additional capability to have industry and academia working in a more joint way. So I'm very much committed to wanting to see one of these develop.

I think there are some other things as part of the whole implementation strategy. The problem is we've got to implement, and implementation is usually the hardest part of the job to do, like building quality hardware that we can test with an get information that doesn't cost an arm and a leg, and we have already begun to demonstrate that.

Maybe we need a CCDS on how to develop commercial quality hardware for research development purposes, and maybe we should have a CCDS in education. There is a company that has come to us on that issue, ways of stimulating our youth again to think about math and science because they are going to be interested in space and what they can see and do, and the way to teach teachers how to do things. This has already been proposed to me.

So there are a number of other areas that maybe lend themselves to a CCDS type arrangement and we should not overlook those as being very valuable in the whole process and the whole evolution of commercializing space.

Mr. VOLKMER. Mr. Schmidt, do you wish to comment on that?

Mr. SCHMIDT. Yes. I think there are a lot of things that could be done and this is what we are really after. NASA is a major customer of ours. We just don't think that the commercial space activity that is in NASA has been given the kind of budgeting and priority that it needs.

I could comment on say that for some of the things that were talked about here why couldn't you make a free flyer that was on a co-orbit with Shuttle and was man visited as opposed to the man tended or manned, and then the 21 or the 31 or 60 days, whatever it takes for it would be easy to do. I think it's within the realm of possibility and I think it's the way we should be looking at developing commercial space research and development.

Mr. VOLKMER. All right, I guess we can close.

I've got to make a little comment as I view where we are and where we've been, and I may be a little wrong, but I guess when we started out in NASA basically it was learning first of all what space was all about, getting there and getting back and the rudimentary things. Then it was research and learning more about what's in the space. I think we are in the development stage right now of what we call another part of it, and that's commercial.

Now some people say that right now all NASA basically has been doing is running a trucking service, you know, comparing the Shuttle basically to that, and seeing a Space Station is not a big thing in science. The question is how far should NASA go beyond in other words space science because I think that was the first thing that NASA was first developed for.

I personally feel that there is room within NASA, not only for space science, and that still has to be a priority, but for commercialization. I don't think otherwise we'll see commercialization. I don't think you're going to see it any other way. If we rely solely on spinoffs from DOD for space programs, we're going to wait a long time. I think that's part of the problem of the money and the priority and everything else.

We haven't talked about commercialization, but what, how many years, Jim, 6 years or 7 years?

Mr. ROSE. I feel like I've been in it forever.

Mr. VOLKMER. Yes, I know, and you have been basically from the beginning. You have been there from the beginning, but it hasn't been very long ago in our total space program.

And I think, Mr. Schmidt, that's probably part of the problem. I appreciate your testimony. I think we need to look at the possibility of giving more emphasis to it and doing more for it if we're going to be able to have a viable commercial policy.

Mr. SCHMIDT. The Europeans and the Asians are coming on pretty strong in commercial space and spending money at it.

Mr. ROSE. No question. I agree with you 100 percent.

Mr. VOLKMER. All right. Thank you very much and that will conclude the hearing.

We appreciate your testimony here today.

[The subcommittee adjourned at 4:20 p.m., subject to the call of the Chair.]

1990 NASA AUTHORIZATION

TUESDAY, APRIL 18, 1989

U.S. House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met at 1:30 p.m., in Room 2359A, Rayburn House Office Building, Hon. Bill Nelson, chairman of the subcommittee, presiding.

Present: Representatives Nelson, Rohrabacher, Lewis, Packard, Smith of Texas, Volkmer, Mineta, Morella, Stallings and Walker.

Mr. **Nelson** [presiding]. Good afternoon. We are going to begin our hearing reviewing the President's budget request for the Department of Transportation's Office of Commercial Space Transportation.

We have a number of witnesses today.

First, we will have Stephanie Lee-Miller. Ms. Miller is the new Director of the DOT's Office of Commercial Space Transportation.

We welcome you. We congratulate you on your appointment, and I understand this is your first appearance before a committee, and relax. We handle it very informally.

Then we are going to hear from our dear friend, Deke Slayton. We welcome him always. His knowledge is always valued in this committee, and we congratulate you on your successful launch of Consort 1, and I believe you are going to be showing a video to us of America's first commercial launch, which was last month, and so we are delighted and we are going to learn a lot from your experience.

Then we are going to hear from the McDonnell-Douglas Corporation, Mr. Alan Kehlet. He is here as a representative of the Commercial Space Transportation Advisory Committee, and we are anxious to hear about his company's plans for their first Delta commercial launch, which is scheduled in late May.

Now, I am told that we have this room until 3:30. So in order to accommodate the committee that owns this room, we are going to have to keep popping right along here.

So let me turn to Mr. Smith of Texas, and he has a statement to enter into the record.

Mr. **Smith**. Thank you, Mr. Chairman.

This hearing is important because it focuses on what hopefully will be a major part of our future space transportation system.

Congress and the Administration have recognized the potential for commercial space transportation, and it is our responsibility to ensure a smooth transition to regular private launch activity in those areas where it is appropriate, commercially desirable, and economically viable.

The interest of the private sector is there. So we must guarantee that federal launch policies facilitate commercial involvement. To do this certain issues must be addressed.

For instance, what assurance will the commercial industry have on a reliable adherence to launch schedules, especially if unforeseen technical problems affect government launch needs.

Successful commercial ventures require predictability, a set of reasonable expectations on which they can base cost projections.

We must also take a hard look at the issue of international competition from the perspectives of technology transfer and maintenance of fair trade practices. Knowing the difficulty that this nation has had with certain trading partners in other markets, it is crucial that Congress encourage, not inhibit, a vigorous launch program that domestic and foreign customers will find attractive.

I believe we will find greater success in making our commercial launch program the best bargain rather than attempting to restrict other nation's programs.

Thank you, Mr. Chairman.

Mr. Nelson. Thank you, Mr. Smith.

This subject that we are exploring today is near and dear to our hearts. We have labored long and hard in this committee going back to 1984 when we enacted the Commercial Space Launch Act, and then we saw that it wasn't working like it should, and for commercial ELVs or rockets, we needed to have some kind of cooperation with the government.

So there had to be risk sharing, and we put together this piece of legislation that just by virtue of the fact that the legislation was moving was enough to get some of the commercial rocket manufacturers moving in the process of getting this thing kicked off.

So we had the government risk sharing in this legislation that became law in October.

Also, the government was going to risk share in the potential destruction of facilities, and we were not going to let the government in an arbitrary fashion by a low level commander make a decision that was going to bump commercial launches, that it was going to have to be in a standard that everyone would agree—imperative national need that a commercial launch could be bumped, but that wasn't going to be decided by a low level commander. That was going to be decided jointly among the Department of Transportation Secretary, the Secretary of Defense, and the NASA Administrator.

We get this legislation going, all this stuff is cranking on, and then, lo and behold, we have the Administration announce that they are going to give an export license for an American made satellite to be launched on a Chinese launch vehicle.

Now, there may be reasons to do that, but they don't have anything to do with trying to undergird the financial viability of the American commercial rocket industry. The reasons may be because of the United States foreign relations with the Peoples Republic of China. There may be extraneous reasons that we need to do that, but that was not a step forward in trying to give a healthy start of a first step to an American commercial rocket industry.

And yet despite all of that, the proof is in the pudding. There are 26 signed contracts for payloads going on American ELVs, and so that is what we want to focus in on this hearing, as abbreviated as it is, and, Ms. Miller, we will start with you. Please share with us.

STATEMENT OF STEPHANIE LEE-MILLER, DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION, DOT, WASHINGTON, DC, ACCOMPANIED BY GERALD MUSARRA, CHIEF COUNSEL; AND MR. NORMAN BOWLES, ASSOCIATE DIRECTOR FOR LICENSING PROGRAMS

Ms. Lee-Miller. Thank you, Mr. Chairman.

Mr. Chairman, members of the subcommittee, thank you for giving me the opportunity to discuss the proposed fiscal year 1990 budget for DOT's Office of Commercial Space Transportation and to address other issues affecting the American commercial space launch industry.

Mr. Chairman, as you have indicated, I am new to this job. However, it is already quite evident to me that the support that you and other subcommittee members have given to the commercial launch initiative over the years has been a key factor in the very real progress that has been made.

Your commitment and those of the other members of this committee to a strong U.S. presence in all space-related activities is known not only in America but worldwide.

As we begin an exciting new chapter in the history of U.S. space endeavors, I would like to say on behalf of Secretary Skinner and the Department of Transportation we thank this committee, and we look forward to working with you and continuing this cooperative effort in the coming years.

I have with me two of my colleagues from the Office of Commercial Space Transportation, who with your permission will help me during the Q and A period with some of the technical areas.

First, I would like to introduce Gerald Musarra, who is Chief Counsel to the Office of Commercial Space Transportation, to my left; and Norman Bowles, who is Associate Director for the Licensing Program.

On February 9th, President Bush presented his budget initiatives to Congress and the nation. At that time he indicated that aggressive pursuit of our varied national objectives in space would be a high priority for this Administration. In particular, he made it clear that the private sector must play an increasingly active, direct role in achieving these objectives.

"We must"—and I quote—"have a manned space station, a vigorous, safe Shuttle program, and more commercial development in space."

OCST is committed to working toward our part of this goal, and I believe it can be done within the framework of a realistic and reasonable budget.

That said, it bears emphasizing that with more than half a dozen firms conducting launches and related operations and with foreign competition heating up on several fronts, the program must be properly funded in order for OCST to perform its oversight and guidance responsibilities effectively.

Therefore, in fiscal year 1990 we are requesting a budget of $4.4 million. Before addressing specific proposed project expenditures, let me take a moment to describe the present focus of our program and several of our recent accomplishments.

First, the major portion of our time and resources is focused on the continuing development of our regulatory program.

Recently, procedures have been augmented for the formal licensing with internal procedures related to the monitoring of licensed activities and the investigation of launch accidents affecting public safety. These measures were in place in order for us to provide appropriate supervision for the very successful SSI launch in March. We are very proud of that launch, as I am sure we all are.

Similar actions are planned for the upcoming launches, notably the McDonnell-Douglas launch from Cape Canaveral in May.

OCST has also been working to achieve prompt implementation of very important 1988 Commercial Space Launch Act amendments, and I am happy to report to you that much progress has been made in all of the significant areas addressed by the amendments.

Section 8 of the amendments direct OCST to study ways to facilitate commercial use of U.S. launch facilities. The OCST staff have evaluated scheduling procedures of launch facilities and have solicited information regarding scheduling requirements from both the launch firms and the user community.

You are expecting a report from us this spring, and we expect to have it up to you on time.

Perhaps most important, in the last several months we have spent a significant amount of time addressing issues associated with the provisions in the amendments pertaining to insurance and other liability-related requirements. This is a very complex area; however, I am happy to report that we are able to establish requirements and did so with the Space Services Incorporated of America's launch pursuant to the provisions of the amended act. We are now on our way to crafting appropriate requirements for the three major launch firms that have launches coming up soon.

In the fiscal year 1990 budget, OCST is requesting 3.6 million to fund research programs and activities and 805,000 for administrative salaries and expenses. Our ability to provide effective regulatory guidance for commercial launch activities is directly affected by the availability of research on safety and launch operation issues.

Our research studies are essential to create a data base that can be adapted to the very unique commercial space context and used to respond to the problems associated with commercial space activity. This kind of data is not available from other government sources. Therefore, OCST must develop it.

For safety research we have requested 1.5 million to fund several projects, including 1,060,000 for research on commercial launch operations and ranges. We are requesting 200,000 for research on environmental safety, 100,000 for research on orbital safety, 100,000 for research on payload safety, 475,000 for support and management of space safety data. OCST is also requesting 575,000 for continued licensing and enforcement operations.

You indicated the time is short. I am kind of moving quickly over the dollar amounts and can go into more detail if you so desire.

OCST is requesting 400,000 to track and maintain information on the capabilities, market developments, and competitiveness of commercial launch providers and customers.

We are developing the Space Transportation Analysis and Research, called STAR, data base to assist in this effort. This automated data base enables OCST to instantly access a wide range of information pertaining to U.S. and foreign commercial launch services.

OCST is requesting 627,000 for research-related salaries and administrative costs, and we are requesting 50,000 to facilitate responses to industry requests for information on its activities.

Mr. Chairman, the Congress and the Administration are allied with American business in the development of a dynamic new industry, the commercial launch industry. We stand jointly on the crest of a wave of aggressive, imaginative activity on the part of a diverse group of companies.

This activity may well contribute much to our future economic well-being, growth, and productivity for many years to come. However, moving boldly into the future is going to require a firm and consistent policy from the government.

As a nation, we can look forward to the technological, economic, and national security benefits of a thriving commercial space industry. Generations that follow us will be grateful for the decisions made today that lay the groundwork for tomorrow.

I realize that all spending decisions are difficult within the current budgetary climate; however, I would hope that we can avoid trading away this nation's future potential in commercial space enterprise in the course of redressing budget ills which have been excesses of the past.

Mr. Chairman, President Bush and our international competitors have certainly issued the challenge to all of us. It is now up to us to respond.

I thank you for this time today, and I am certainly happy to answer any questions that you may have, and as I indicated, my associates are here with me to assist me in responding to the questions from the committee.*

[The prepared statement of Ms. Lee-Miller follows:]

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* Appendix 11 contains additional answers to questions asked of Ms. Lee-Miller following this hearing of April 18, 1989. See p. 1255.

STATEMENT OF
STEPHANIE LEE-MILLER
DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION
U.S. DEPARTMENT OF TRANSPORTATION

BEFORE THE

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
APRIL 18, 1989

MR. CHAIRMAN, MEMBERS OF THE SUBCOMMITTEE, THANK YOU FOR GIVING ME THE OPPORTUNITY TO DISCUSS THE PROPOSED FISCAL YEAR 1990 BUDGET FOR THE DEPARTMENT'S OFFICE OF COMMERCIAL SPACE TRANSPORTATION (OCST) AND TO ADDRESS OTHER ISSUES AFFECTING THE AMERICAN COMMERCIAL SPACE LAUNCH INDUSTRY.

MR. CHAIRMAN, I AM, AS YOU KNOW, NEW TO THIS JOB. IT IS, HOWEVER, ALREADY QUITE EVIDENT TO ME THAT THE SUPPORT THAT YOU AND THE OTHER SUBCOMMITTEE MEMBERS HAVE GIVEN TO THE COMMERCIAL LAUNCH INITIATIVE OVER THE YEARS HAS BEEN A KEY FACTOR IN THE VERY REAL PROGRESS THAT HAS BEEN MADE. YOUR COMMITMENT TO A STRONG U.S. PRESENCE IN ALL SPACE-RELATED ACTIVITIES IS WELL KNOWN. AS WE BEGIN AN EXCITING NEW CHAPTER IN THE HISTORY OF U.S. SPACE ENDEAVORS, I WOULD LIKE TO SAY, ON BEHALF OF SECRETARY SKINNER AND THE DEPARTMENT OF TRANSPORTATION, I LOOK FORWARD TO WORKING WITH YOU AND CONTINUING THIS COOPERATIVE EFFORT IN THE COMING YEARS.

ON FEBRUARY 9, PRESIDENT BUSH PRESENTED HIS BUDGET INITIATIVES TO CONGRESS AND THE NATION. AT THAT TIME, HE INDICATED THAT AGGRESSIVE PURSUIT OF OUR VARIED NATIONAL OBJECTIVES IN SPACE WOULD BE A HIGH PRIORITY FOR HIM. IN PARTICULAR, HE MADE IT CLEAR THAT THE PRIVATE SECTOR MUST PLAY AN

INCREASINGLY ACTIVE, DIRECT ROLE IN ACHIEVING THESE OBJECTIVES.

"WE MUST," HE SAID, "HAVE A MANNED SPACE STATION, A VIGOROUS, SAFE SHUTTLE PROGRAM, AND MORE COMMERCIAL DEVELOPMENT IN SPACE."

OCST IS COMMITTED TO WORKING TOWARD OUR PART OF THIS GOAL, AND I BELIEVE IT CAN BE DONE WITHIN THE FRAMEWORK OF A REALISTIC AND REASONABLE BUDGET. THAT SAID, IT BEARS EMPHASIZING THAT WITH MORE THAN HALF A DOZEN FIRMS CONDUCTING LAUNCHES AND RELATED OPERATIONS, AND WITH FOREIGN COMPETITION HEATING UP ON SEVERAL FRONTS, THE PROGRAM MUST BE PROPERLY FUNDED IN ORDER FOR OCST TO PERFORM ITS OVERSIGHT AND GUIDANCE RESPONSIBILITIES EFFECTIVELY.

FOR FISCAL YEAR 1990, WE ARE REQUESTING A TOTAL BUDGET OF $4.4 MILLION. BEFORE ADDRESSING SPECIFIC PROPOSED PROJECT EXPENDITURES, LET ME TAKE A MOMENT TO DESCRIBE THE PRESENT FOCUS OF THE PROGRAM AND SEVERAL OF OUR RECENT ACCOMPLISHMENTS.

* * *

FIRST, THE MAJOR PORTION OF OUR TIME AND RESOURCES IS FOCUSED ON THE CONTINUING DEVELOPMENT OF OUR REGULATORY PROGRAM. LAST YEAR, THE OFFICE PUBLISHED FINAL LICENSING REGULATIONS WHICH PROVIDE THE ADMINISTRATIVE FRAMEWORK FOR OVERSEEING THE BROAD RANGE OF LAUNCH ACTIVITIES THAT ARE BEING CONDUCTED OR PLANNED.

MORE RECENTLY, WE AUGMENTED THESE FORMAL PROCEDURES WITH INTERNAL ONES RELATING TO THE MONITORING OF LICENSED ACTIVITIES AND THE INVESTIGATION OF LAUNCH ACCIDENTS AFFECTING PUBLIC SAFETY. THESE MEASURES WERE IN PLACE IN ORDER FOR US TO PROVIDE

APPROPRIATE SUPERVISION FOR THE SPACE SERVICES INCORPORATED OF AMERICA LAUNCH IN MARCH. SIMILAR ACTIONS ARE PLANNED FOR THE UPCOMING LAUNCHES, NOTABLY THE MCDONNELL DOUGLAS LAUNCH FROM CAPE CANAVERAL IN MAY.

IN MEETING ITS MANDATE TO LICENSE COMMERCIAL LAUNCH ACTIVITIES TO ENSURE THAT THEY ARE CONDUCTED AS SAFELY AS POSSIBLE, OCST HAS COMPLETED OR IS COMPLETING BASELINE ASSESSMENTS OF FOUR EXISTING LAUNCH RANGES: WHITE SANDS MISSILE RANGE, EASTERN SPACE AND MISSILE CENTER, VANDENBERG AIR FORCE BASE AND WALLOPS ISLAND FLIGHT FACILITY. THESE ASSESSMENTS ARE ONE OF SEVERAL ANALYTICAL BASES OCST USES TO EVALUATE AN APPLICANT'S LAUNCH SAFETY PLANS. OTHER ANALYTICAL BASES INCLUDE A MAJOR, COMPREHENSIVE SAFETY STUDY WE ISSUED, "HAZARD ANALYSIS OF COMMERCIAL SPACE TRANSPORTATION," AND THE INTER-AGENCY REPORT ON ORBITAL DEBRIS HAZARDS.

THIS INFORMATION, ALONG WITH ACTIVITIES IN ASSESSING AND EVALUATING LAUNCH RISKS, AND INSPECTING LAUNCH SITES, VEHICLES AND PAYLOADS, ENABLES OCST TO MEET ITS REGULATORY OBLIGATIONS AND SET APPROPRIATE INSURANCE REQUIREMENTS.

TO DATE, OCST HAS ISSUED LAUNCH LICENSES TO THREE COMPANIES (MCDONNELL DOUGLAS, CONATEC, SPACE SERVICES INCORPORATED OF AMERICA); WE EXPECT TO ACT ON AT LEAST SIX MORE LICENSE APPLICATIONS THIS YEAR.

OCST HAS ALSO BEEN WORKING TO ACHIEVE PROMPT IMPLEMENTATION OF THE 1988 COMMERCIAL SPACE LAUNCH ACT AMENDMENTS, AND I AM HAPPY TO REPORT TO YOU THAT MUCH PROGRESS HAS BEEN MADE IN ALL THE

SIGNIFICANT AREAS ADDRESSED BY THE AMENDMENTS.

SECTION 8 OF THE AMENDMENTS DIRECTS OCST TO STUDY WAYS TO FACILITATE COMMERCIAL USE OF U.S. LAUNCH FACILITIES. OCST STAFF HAVE EVALUATED SCHEDULING PROCEDURES OF LAUNCH FACILITIES AND SOLICITED INFORMATION REGARDING SCHEDULING REQUIREMENTS FROM BOTH THE LAUNCH FIRMS AND THE USER COMMUNITY. WE EXPECT TO REPORT OUR STUDY FINDINGS TO CONGRESS THIS SPRING.

SECTION 6 OF THE AMENDMENTS PROVIDE INCENTIVES FOR SATELLITES THAT WERE OFF-LOADED FROM THE SHUTTLE TO USE DOMESTIC COMMERCIAL LAUNCH VEHICLES. OCST IS CURRENTLY WORKING TO IDENTIFY THE SATELLITES THAT ARE ELIGIBLE FOR THESE INCENTIVES AND IS WORKING WITH INDUSTRY AND OTHER GOVERNMENT AGENCIES TO DEVELOP MECHANISMS FOR ACHIEVING THE ACT'S OBJECTIVES IN THIS AREA.

PERHAPS MOST IMPORTANT, IN THE LAST SEVERAL MONTHS WE HAVE SPENT A SIGNIFICANT AMOUNT OF TIME ADDRESSING ISSUES ASSOCIATED WITH THE PROVISIONS IN THE AMENDMENTS PERTAINING TO INSURANCE AND OTHER LIABILITY-RELATED REQUIREMENTS. ALTHOUGH THIS IS A VERY COMPLEX AREA, I AM, ONCE AGAIN, HAPPY TO REPORT THAT WE WERE ABLE TO ESTABLISH REQUIREMENTS FOR SPACE SERVICES INCORPORATED OF AMERICA'S LAUNCH PURSUANT TO THE PROVISIONS OF THE AMENDED ACT. WE ARE NOW WELL ON OUR WAY TO CRAFTING APPROPRIATE REQUIREMENTS FOR THE THREE MAJOR LAUNCH FIRMS.

ANOTHER ACHIEVEMENT IS AN AGREEMENT WITH THE FEDERAL EMERGENCY MANAGEMENT AGENCY TO ALLOW THE COMMERCIAL SECTOR TO RECEIVE PRIORITY FOR ALLOCATION OF SCARCE SOLID ROCKET FUEL.

* * *

ANOTHER IMPORTANT FOCUS OF OUR EFFORTS INVOLVES THE MULTIFACETED AREA OF INTERNATIONAL COMPETITION. THE ISSUES ENCOMPASS NOT ONLY OUR EFFORTS TO FURTHER THE ADMINISTRATION'S AND THIS COMMITTEE'S COMMON OBJECTIVE OF SECURING A "LEVEL PLAYING FIELD" FOR U.S. FIRMS, BUT ALSO OUR EFFORTS TO ENSURE THAT U.S. FIRMS CAN MEET THE CHALLENGE POSED BY NEW COMPETITORS LIKE THE PEOPLES REPUBLIC OF CHINA. OCST WAS THE FIRST OFFICE IN THE EXECUTIVE BRANCH TO RECOGNIZE THE IMPLICATIONS FOR U.S. COMMERCIAL LAUNCH PROVIDERS POSED BY ENTRY OF THE CHINESE GOVERNMENT AS A MARKET COMPETITOR AND WAS VERY ACTIVE IN THE ADMINISTRATION TO ENSURE THAT CHINA'S ENTRY WAS CONDITIONED BY APPROPRIATE SAFEGUARDS.

DOT HAS ALSO SERVED AS THE LEAD AGENCY SUPPORTING THE EFFORTS OF THE U.S. TRADE REPRESENTATIVE TO ASSESS THE UTILITY OF A FORMAL TRADE ARRANGEMENT WITH THE EUROPEAN SPACE AGENCY AND TO DEVELOP APPROPRIATE TRADE PRINCIPLES. THAT EFFORT IS ONGOING AND WILL CONTINUE TO BE A PRIME FOCUS THIS SPRING.

THE CHALLENGE BEFORE US IS NOT SIMPLY ONE OF ENCOURAGING FOREIGN LAUNCH SERVICE PROVIDERS, BACKED BY EXTENSIVE GOVERNMENT SUPPORT, TO COMPETE FAIRLY WITH U.S. FIRMS. WE ALSO FACE THE EVEN MORE DIFFICULT TASK OF FACILITATING THE DEVELOPMENT OF AN INTERNATIONAL INDUSTRY ON THE BASIS OF ECONOMIC VALUES AND PRACTICES OUR COUNTRY HAS LONG SOUGHT TO INFUSE IN THE INTERNATIONAL MARKETPLACE. IN THE END, IT IS CHIEFLY THROUGH THIS

MEANS THAT THE LONG-TERM COMPETITIVENESS OF THE U.S. LAUNCH INDUSTRY CAN BE ASSURED.

WE HAVE OUR WORK CUT OUT FOR US; OUR FOREIGN COMPETITORS ARE EAGERLY JOINING THE COMMERCIAL SPACE RACE. ARIANESPACE CURRENTLY HAS AN ORDER BOOK OF 34 SATELLITE PAYLOADS WITH A TOTAL ORDER VALUE OF $2.4 BILLION, AND IT HAS LAUNCHED 17 SATELLITE PAYLOADS SINCE 1988.

AS I MENTIONED BEFORE, THE PEOPLES REPUBLIC OF CHINA HAS AGREEMENTS TO LAUNCH SATELLITES FOR FOREIGN CUSTOMERS. AND, WITH DEVELOPMENT OF THE H-2 LAUNCH VEHICLE, JAPAN HAS SET THE STAGE FOR ITS ENTRANCE INTO THE COMMERCIAL LAUNCH MARKETPLACE. THESE ACTIVITIES HAVE A BIG IMPACT ON OUR COMPANIES' PLANS AND ABILITY TO EFFECTIVELY COMPETE.

CLEARLY, THE U.S. HAS THE CAPABILITY AND THE WILL TO BE A STRONG COMPETITOR IN THE WORLD MARKET. WE CONTINUE TO VIGOROUSLY RESPOND TO THESE DEVELOPMENTS SO THAT WE CAN PLAY A MAJOR LEADERSHIP ROLE IN THE WORLDWIDE COMMERCIAL LAUNCH MARKET IN THE YEARS TO COME.

* * *

IN THE FISCAL YEAR 1990 BUDGET, OCST IS REQUESTING $3.6 MILLION TO FUND RESEARCH PROGRAM ACTIVITIES AND $805,000 FOR ADMINISTRATIVE SALARIES AND EXPENSES.

OCST'S ABILITY TO PROVIDE EFFECTIVE REGULATORY GUIDANCE FOR COMMERCIAL LAUNCH ACTIVITIES IS DIRECTLY AFFECTED BY THE AVAILABILITY OF RESEARCH ON SAFETY AND LAUNCH OPERATION ISSUES.

OUR RESEARCH STUDIES ARE ESSENTIAL TO CREATE A DATABASE THAT CAN BE ADAPTED TO THE UNIQUE COMMERCIAL SPACE CONTEXT AND USED TO RESPOND TO THE PROBLEMS ASSOCIATED WITH COMMERCIAL SPACE ACTIVITY. THIS KIND OF DATA IS NOT AVAILABLE FROM OTHER GOVERNMENT SOURCES; OCST MUST DEVELOP IT.

FOR SAFETY RESEARCH, WE HAVE REQUESTED $1.5 MILLION TO FUND SEVERAL PROJECTS, INCLUDING:

* RESEARCH ON COMMERCIAL LAUNCH OPERATIONS AND RANGES ($1,060,000). EXISTING LAUNCH FACILITIES AND OPERATIONS USED BY NASA AND THE MILITARY MAY NOT BE ENTIRELY APPROPRIATE FOR, OR ADAPTABLE TO FUTURE COMMERCIAL LAUNCH ACTIVITIES. THEREFORE, OCST MUST STUDY EXISTING SITE CONDITIONS, LAUNCH OPERATION PROCEDURES, PERSONNEL CERTIFICATION, AND EQUIPMENT AND DESIGN REQUIREMENTS. THE STUDY FINDINGS WILL BE USED TO DEVELOP CRITERIA APPROPRIATE FOR FUTURE COMMERCIAL LAUNCH SITES, ACTIVITIES AND PERSONNEL.

ALSO, IN THE SHORT RUN, THIS DATA IS REQUIRED TO EVALUATE THE SAFETY OF COMMERCIAL OPERATIONS AND EXISTING LAUNCH FACILITIES. THESE FACILITIES WERE DESIGNED TO SUPPORT GOVERNMENT OPERATIONS. THE BEGINNING OF COMMERCIAL ACTIVITIES AT THESE FACILITIES HAS CREATED PROFOUND CHANGES IN THE ROLES OF THE RANGE AND THE LAUNCH OPERATOR. ALSO, AS THE LAUNCH INDUSTRY INTRODUCES NEW VEHICLES AND NEW OPERATING STYLES TO THESE FACILITIES, OVERALL SAFETY LEVELS ARE AFFECTED; THE IMPACT OF THESE EVENTS MUST BE TRACKED.

* RESEARCH ON ENVIRONMENTAL SAFETY ($200,000). OCST MUST

REVIEW THE IMPACT OF COMMERCIAL LAUNCHES ON NEARBY LAND, WATER, ATMOSPHERE AND WILDLIFE TO ENSURE THAT PROPOSED LAUNCHES WILL BE CONDUCTED IN CONFORMITY WITH NATIONAL ENVIRONMENTAL POLICY ACT REQUIREMENTS.

* RESEARCH ON ORBITAL SAFETY ($100,000). THE DEVELOPMENT OF EFFECTIVE SAFETY STANDARDS INCLUDES ASSESSING ON-ORBIT AND RE-ENTRY HAZARDS TO COMMERCIAL LAUNCH VEHICLES AND DANGERS TO INDIVIDUALS AND PROPERTY ON EARTH.

* RESEARCH ON PAYLOAD SAFETY ($100,000). AS COMMERCIAL LAUNCHES GET UNDERWAY AND NEW TECHNOLOGY IS INTRODUCED INTO THE LAUNCH SERVICES MARKET, NEW PAYLOADS WILL BE DEVELOPED. OCST MUST REVIEW THESE NEW PAYLOADS TO ENSURE THEY MEET APPROPRIATE SAFETY STANDARDS.

OCST IS REQUESTING A TOTAL OF $475,000 FOR SUPPORT AND MANAGEMENT OF SPACE SAFETY DATA.

THIS ENTAILS DESIGNING AND IMPLEMENTING COMPUTER SYSTEM SOFTWARE AND HARDWARE USED TO TRACK OCST'S LICENSING ACTIVITIES, AND DEVELOPING PERFORMANCE MEASURES TO ANALYZE FLIGHTS AND RISK MODELS TO ASSESS FUTURE LAUNCHES. IT ALSO INCLUDES FUNDING FOR CONTINUED TRANSPORTATION SYSTEMS CENTER RESEARCH AND DEVELOPMENT IN SUPPORT OF OCST'S PROGRAMS.

OCST IS REQUESTING $575,000 FOR CONTINUED LICENSING AND ENFORCEMENT OPERATIONS.

THIS INCLUDES ONGOING LICENSE REVIEW ACTIVITIES, AND DEVELOPMENT OF INSPECTION METHODOLOGY AND ACCIDENT INVESTIGATION

PROCEDURES FOR COMMERCIAL LAUNCHES. IN THIS CONTEXT, IT IS IMPORTANT TO STOP AND NOTE THE SHARP INCREASE IN THE NUMBER OF LICENSE APPLICATIONS. IN 1988, OCST REVIEWED SIX LAUNCH APPLICATIONS. IN 1989, WE EXPECT UP TO NINE, AND IN 1990, WE ANTICIPATE HANDLING UP TO 20 APPLICATIONS.

OCST IS REQUESTING $400,000 TO TRACK AND MAINTAIN INFORMATION ON THE CAPABILITIES, MARKET DEVELOPMENTS, AND COMPETITIVENESS OF COMMERCIAL LAUNCH PROBIDERS AND CUSTOMERS.

WE ARE DEVELOPING THE SPACE TRANSPORTATION ANALYSIS AND RESEARCH (STAR) DATABASE SYSTEM TO ASSIST IN THIS EFFORT. THIS AUTOMATED DATABASE ENABLES OCST TO INSTANTLY ACCESS A WIDE RANGE OF INFORMATION PERTAINING TO U.S. AND FOREIGN COMMERCIAL LAUNCH SERVICES. STAR CONTAINS DATA ON THE PHYSICAL CHARACTERISTICS OF EXISTING AND PROJECTED LAUNCH VEHICLES, KNOWN CONTRACTS FOR LAUNCH SERVICES, AND POTENTIAL PAYLOADS FOR FUTURE LAUNCHES. SOME OF THE REQUESTED FUNDS WILL BE USED TO ENHANCE THE STAR DATABASE, WITH CRITICAL OBJECTIVES BEING THE DEVELOPMENT OF A COMPREHENSIVE MARKET FORECASTING CAPABILITY AND THE IMPROVEMENT OF COST AND PRICE COMPONENTS.

OCST IS REQUESTING $627,000 FOR RESEARCH-RELATED SALARIES AND ADMINISTRATIVE COSTS.

OCST IS REQUESTING $50,000 TO FACILITATE RESPONSES TO INDUSTRY REQUESTS FOR INFORMATION ON ITS ACTIVITIES.

* * *

MR. CHAIRMAN, THE CONGRESS AND THE ADMINISTRATION ARE ALLIED

WITH AMERICAN BUSINESS IN THE DEVELOPMENT OF A DYNAMIC NEW INDUSTRY -- THE COMMERCIAL LAUNCH INDUSTRY. WE STAND JOINTLY ON THE CREST OF A WAVE OF AGGRESSIVE, IMAGINATIVE ACTIVITY ON THE PART OF A DIVERSE GROUP OF COMPANIES. THIS ACTIVITY MAY WELL CONTRIBUTE MUCH TO OUR FUTURE ECONOMIC WELL-BEING, GROWTH AND PRODUCTIVITY FOR MANY YEARS TO COME. HOWEVER, MOVING BOLDLY INTO THE FUTURE IS GOING TO REQUIRE A FIRM AND CONSISTENT POLICY FROM THE GOVERNMENT.

AS A NATION WE CAN LOOK FORWARD TO THE TECHNOLOGICAL, ECONOMIC AND NATIONAL SECURITY BENEFITS OF A THRIVING COMMERCIAL SPACE INDUSTRY. GENERATIONS THAT FOLLOW US WILL BE GRATEFUL FOR THE DECISIONS MADE TODAY THAT LAY THE GROUNDWORK FOR TOMORROW. I REALIZE THAT ALL SPENDING DECISIONS ARE DIFFICULT WITHIN THE CURRENT BUDGETARY CONTEXT. HOWEVER, I WOULD HOPE THAT WE CAN AVOID TRADING AWAY THIS NATION'S FUTURE POTENTIAL IN COMMERCIAL SPACE ENTERPRISE IN THE COURSE OF REDRESSING BUDGET ILLS WHICH HAVE BEEN EXCESSES OF THE PAST.

MR. CHAIRMAN, PRESIDENT BUSH AND OUR INTERNATIONAL COMPETITORS HAVE ISSUED THE CHALLENGE. IT'S NOW UP TO US TO RESPOND. THANK YOU FOR THIS TIME TODAY, AND I AM HAPPY TO ANSWER ANY QUESTIONS YOU MAY HAVE. WITH ME AT THE TABLE ARE MR. GERALD MUSARRA, OCST'S PROGRAM COUNSEL, AND MR. NORMAN BOWLES, ASSOCIATE DIRECTOR FOR LICENSING PROGRAMS. WITH YOUR PERMISSION, THEY WILL ASSIST ME IN RESPONDING TO ANY QUESTIONS.

# # #

STEPHANIE LEE-MILLER
DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION

Stephanie Lee-Miller became Director, Office of Commercial Space Transportation, on April 1, 1989.

In 1983 she was appointed Assistant Secretary for Public Affairs at the Department of Health and Human Services (HHS). At HHS she was responsible for managing all departmental communications, including media relations and speechwriting. She also served as the Secretary's principal advisor on public affairs issues and the Freedom of Information Act.

In 1981 she came to Washington, D.C., from California, and served for two years in the Public Affairs Office at the Department of Commerce.

Ms. Lee-Miller was born in Los Angeles, California, March 7, 1950. She received her bachelor of arts degree in psychology from California State College at Dominguez Hill in 1971 and the master's degree in urban studies from Occidential College in 1975.

For five years Ms. Lee-Miller was with the Coro Foundation of Los Angeles, the first nine months as a fellow in public affairs and then as director of community programs for the foundation. In 1978 Ms. Lee-Miller became director of the NAACP Legal Defense and Educational Fund for the Southern California area.

From July 1979 until February 1981, when she took leave to enter government service, Ms. Lee-Miller was co-owner and managing partner of Contact California in Beverly Hills, a public relations/public affairs consulting firm that provides media relations, marketing and other account services to private companies and non-profit organizations.

Ms. Lee-Miller served as a member of the U.S. delegation to the International Women's Conference in Nairobi, Kenya, in 1985 and in 1987 served as a member of the U.S. delegation to the United Nations Commission on the Status of Women.

While in California Ms. Lee-Miller's civic, educational and charitable involvements included membership on the board of directors, Los Angeles Chamber of Commerce women's Division; vice chairperson, Community and Government Affairs Council, United Way; member, National Council of Negro Women; member, Delta Sigma Theta Sorority.

Among her awards and honors are: 1977 Outstanding Young Women Award, Los Angeles International Soroptimists; Who's Who Among Black Americans, 1980; Outstanding Young Women of America, 1981; and Outstanding Performance certificate, Secretary of Commerce, 1983.

Ms. Lee-Miller is a Californian currently residing in the District of Columbia.

April 1989

Mr. **Nelson**. Let me ask Mr. Slayton and Mr. Kehlet, if you all would come up, and we are going to take your statements, and then we will get into questions of all of the witnesses.

You gentlemen probably are going to have to give up your seats so that we can accommodate everybody here.

Deke, why don't you take it first? Tell us about your launch.

STATEMENT OF DONALD K. SLAYTON, SPACE SERVICES, INC., HOUSTON, TX

Mr. **Slayton**. All right, sir. We appreciate the opportunity to come and brief you on a small launch here, and I think probably we can save everybody a lot of time and make it more entertaining by running a strip of video we have here. It may be a little longer than you really want, but it shows some of the pre-flight stuff and the flight and a little post-flight.

I have an outline here which I will make a few comments, if you please, after you look at the film.

Mr. **Nelson**. Okay, thank you.

Mr. **Slayton**. This, incidentally, was a free-lance film. We didn't have anything to do with putting it together, and it was contributed to us. So we take no responsibility. Typical entrepreneurial approach to life here.

[Video shown.]

Well, I think that probably says more than I am going to be able to say about the whole thing, or more than is necessary.

Just a couple of comments. I think everybody is aware, of course, that this was the first commercial launch done under a DOT license, and we view that as significant.

But I think the real significance, as Dr. Lundquist mentioned in the film, it showed that we can in fact take the private sector, the academic community, and the government as a partner and put something like this together and make it economically feasible, and in this particular flight we used the government—obviously, NASA Office of Commercial Space were the guys that created this idea, and so they get the credit for it, but we worked with the Department of Transportation to get our licenses. We also used—a little bit unusual—NASA, the Army, and the Navy as subcontractors.

The way White Sands is set up is a little different than most of the other ranges. It is run by the Army. NASA operates there and the Navy operates there, and our interface under the range was through the Navy. So we had our memorandum of understanding actually with the Navy.

But we had very, very good support from everybody on the government side and on the private side. We are very delighted with it.

Our job really was to satisfy the University of Alabama and give them a good flight, and we were the catalyst between them and all the other suppliers.

The vehicle configuration, I think it was said enough about that on the film and nothing more required there.

And the flight profile, you might have not understood what you were seeing there. That first stage motor burns very fast, just 4 seconds. Then it has got a 10-second coast and then about a 30-second burn on the second stage. And that first stage does come back down very close to the blockhouse, about 500 yards. So that is a good reason to have a blockhouse.

The mission went perfect. We had a couple small things. If you have seen any of the still photos, you may see what looks like a minor explosion as it was coming off the pad, and what is going on there, we had to have a styrofoam thermal protection around the payload to protect it, to keep the temperature up on it, and the vehicle flies through that at launch. So it looks like a minor explosion when it comes off the launcher. That is what that was all about.

All in all, we were delighted with the performance of everything.

As far as the government/industry interfaces are concerned, as I already said, I think we have got no problems with any of that. We worked through the DOT, which the discussion today is all about of course. They required us to have a launch license. This is our application for a launch license, which you can see is not very voluminous, and there is our license, which is a one-page document.

So we think this is a trend in the right direction to keep the paper mill down.

And they also set our insurance requirements. We did—and I will say more about that here in a minute—they also reviewed our safety, reviewed all of our safety documents and did onsite reviews. They participated in our flight readiness reviews, reviewed the blockhouse, the control center, and were in fact onsite during the launch.

I haven't heard a report back. I don't know whether you guys were happy with what we did or not, but I guess we will find out.

As far as the problems areas—and I don't view any of these as being a big deal because I think they are all fixed as of now—but we did have some problems with the licensing, primarily because of the short fuse on this flight. We contracted in October for a March launch, and the modification of the Space Act I think was made official in November. DOT was supposed to have six months to revise their procedures based on that, and we had about two to get an answer from them.

So we had a lot of pressure on the system to run that first one through, and there was some interpretation that had to get made. We are dealing with four new pages versus what was one small paragraph on insurance, specifically, and there were some problems sorting that out, but I think that is all straightened out now.

We had some problems with the Navy trying to define what they called unlicensed liability, again related to the same issue. We were not allowed to bring our motor onsite until we had a definition of our insurance.

Fortunately, we had an agreement with NASA for the last two years to use Wallops Island. So it only took a modification of that for White Sands to use the NASA things. We had to again run through a whole new ball of wax with the Navy because they never experienced this system before and they couldn't figure out who had authority to sign it, and we discovered the government doesn't know how to accept money.

We were obligated to pay them in advance, and I went over there with a check to hand them and they wouldn't accept it because they didn't know who had authority to accept it. So hopefully we have taught the government how to accept money from the private sector. That is another aspect of this.

Anyway, I think the conclusion is that we believe the legislation that you gentlemen have put in place is excellent and adequate to service our needs. We don't see anything else required there. I think there does need to be some emphasis on implementation because there are still some growing pains related to that, but again that surely will happen in due time.

And I think the DOT function is much clearer now than it was at the start of this process, and again I hope Norm would agree that that is probably true.

And the benefits of the commercial approach—these aren't our numbers, but we have been told that generally it is five times cheaper and three times faster to do the same project commercially than it is letting the government do it, and we are also aware that there have been some speculation about that the private sector is likely to be reckless and irresponsible and the government has to look over their shoulder, and we discovered that—part of it based on our manned flight experience and applying some of that rigor to an unmanned system—that we—I just was not happy doing things the way they were doing them out there, and we were very much interested in having a safer operation.

For that reason, plus being commercial and having insurance, we do not want to take any risk that is going to raise our insurance premiums in the future. So we are driven by those two factors to be extremely safe, and we think we are.

I will be available for questions at your convenience. Thank you.

Mr. **NELSON**. Mr. Kehlet.

STATEMENT OF ALAN B. KEHLET, VICE PRESIDENT AND GENERAL MANAGER, SPACE TRANSPORTATION, McDONNELL-DOUGLAS SPACE SYSTEMS CO., HUNTINGTON, CA

Mr. **KEHLET**. Thank you.

Mr. Chairman, members of the Space Science and Applications Subcommittee, I am pleased to be here today to report from the Commercial Space Transportation Advisory Committee, or COMSTAC.

All of the members of COMSTAC are involved in this emerging commercial launching industry. We are working with the Department of Transportation in order to forge a more viable industry through a more cooperative attitude on both the part of the industry and the part of government. We cannot afford the adversarial attitude that exists in some other of the private and industry relationships.

We would like to commend this committee for its timely last year of the Commercial Space Act amendments of 1988. This legislation helped to remove some of the uncertainties that Deke talked about involved in indemnification of a commercial ELV launch, by setting the boundaries of third party and property risk.

For instance, we at McDonnell-Douglas Corporation signed an agreement with a customer for a launch approximately three years ago. While we are still in the process of securing insurance for this launch, which is about a month away, the bill will make it easier for the insurance underwriters and, as a consequence, easier for the launchers and satellite owners and operators to do business.

In recent years there has been some erosion of America's preeminence in space because of a number of reasons—the Challenger tragedy, fluctuations in our space policies, and the federal budget. We feel that a healthy commercial launch industry can contribute to our world leadership role and, as a result, our international prestige, more domestic jobs, and stronger balance of trade.

We are all striving towards the same goal, to assure that the United States attains a viable market share in the world market.

I would like to outline five issues which may require some attention as we move into this new era for our industry and for this nation.

The first is cooperation between government and industry.

As I mentioned earlier, there seems to be an adversarial air that has grown between the industry and government. If this emerging industry is to survive, we cannot allow this attitude to interfere. The launch manufacturers need to keep our costs down and our quality and reliability high. Anything that negatively impacts cost, quality, or reliability will ultimately make the U.S. less competitive worldwide.

One factor that would contribute to cost reduction is the transition to a uniform commercial launch services approach, common to both the government and the private sector. While national policy encourages simplification of government contracting practices and encourages the government to procure launch services commercially, there is still a wide gulf between policy and actual implementation, although NASA is proposing to procure launch services in its upcoming mixed fleet RFP.

Another way to keep costs down is to build both government and commercial vehicles on a common production line. This is what we do at Delta. The advantage to the government is common parts and less cost. If this is done, however, we are required to have government inspection of all vehicles, whether they be government or commercial.

The disadvantage to the commercial customer can be increased costs for inspections. We are also required to deliver such items as reports, which may impose additional costs, but do not assist in management or contribute to quality.

The ability of our industry to compete for international market share will be dependent on price, assuming high quality and reliability. Any actions by the federal government which causes increases in costs will force us to be less competitive in the long run.

The second issue has to do with access to U.S. ranges by foreign nationals.

Prior to the transfer of the NASA ELV facilities at Cape Canaveral to the Air Force, our industry dealt with NASA for clearance of foreign nationals, both press and customers. This process usually took 30 days or less for normal clearance and in an emergency we could get it done in two or three days. However, now that we must work through the Air Force, the process averages about 60 days. The procedure has to be initiated through a foreign national's embassy and involves a lengthy review process by the International Affairs Division of the Air Force.

Our foreign customers have reacted strongly against this change in policy, as you can imagine. They are frustrated and even insulted at this change. We have received more than one nasty-gram from the people of Canada and the people of Britain.

We must keep in mind that the foreign satellite customers have an increasing choice of launch service providers and an important factor for the customers includes user friendly ease of access to his property or satellite.

We at McDonnell-Douglas are scheduled to launch the first orbital commercial satellite the end of May, and we hope you all will be able to attend this historic event.

Recently, we were informed by the Air Force that all foreign nationals will require an official escort while on the launch site. This is a major milestone for our industry and for our nation, this launch. We expect foreign press coverage, foreign diplomatic officials, and foreign technicians at this launch. It is a monumental job to get everyone cleared who should be invited.

COMSTAC has initiated a subcommittee to address this issue. The Air Force recognizes the industry concerns and is trying to work with industry to make the system work a little more effectively for industry. The Air Force is also developing a model visit request which is geared to expedite the clearance process. Even if this process is accelerated, however, the escort requirement is cumbersome and costly. In the case of an emergency, an uncleared foreign national technical personnel may be denied access to the launch site.

The third issue has to do with an extension of a restricted area.

Another requirement that was the result of the shift of launch facilities from NASA to the Air Force is an increase in launch security requirements. The security requirement, called Wide Area Detection Intrusion System, WADE System, goes into effect 75 hours prior to launch. The WADE System was originally established for DOD classified launches and involves 42 security police stationed around the launch complex, aircraft and helicopter overflights, and Coast Guard protection as well. This contrasts to the normal range safety, which requires only seven security police to set up roadblocks about 24 hours in advance.

The commercial launch cost to engage the WADE System is approximately $250,000, with an additional cost of $60,000 per day in the event of launch slippage. The Air Force contends that these costs must be passed on to the launcher because the Air Force is prohibited by law from direct subsidies of the commercial launches. However, one of our companies has negotiated a range use agreement which may ease this requirement for them in the future. The concept, however, is yet to be tested and does point out some inconsistencies in Air Force application of security requirements.

The fourth issue I have is a change in the telemetry frequency assignments.

Last month, the Federal Communications Commission, FCC, issued a Notice for Proposed Rulemaking, NPRM, which would require commercial launchers to use different telemetry bands than the DOD or government bands previously used. Comments from industry were due yesterday to the FCC and we will probably have a regulation finalized by midsummer.

Currently, commercial launchers use the 2200 to 2290 MHz DOD frequency for both U.S. Government launches and for the private industry launches.

COMSTAC has recently formed a working group, headed by George Koopman, President and CEO of AMROC, to address the potential application of the changeover to commercial bands and the appropriate time frame for this implememtation.

If this regulation is implemented, the impact will be that we will be required to change our telemetry system in the commercial vehicles, increasing the costs for the commercial launchers. This telemetry, I might point out, is used for only about two hours after launch.

The current commonality of transmitters provides smart logistics and enhances DOD's ability to react to an emergency situation, or we may have to change our telemetry system.

The use of uncommon transmitters, however, complicates logistics, in that we must spare now for both the commercial and government launches.

We would recommend that for commercial ELVs, especially those where the vehicle is common with a DOD payload, that the commercial be allowed to use the same frequency; that is, the 2200 to 2290, as we have used before.

The last issue I have is closing of the NASA ground stations.

In September 1989, this year, NASA is scheduled to close its ground station on Ascension Island and about a year later its ground station at Dakar, Senegal. These are closures resulting from having the TDRSS in place for the Space Shuttle and will save NASA funding once all the ground stations are closed.

While we understand the NASA point of view, we are concerned about the impact now that the ELV industry exists and the Shuttle is not the only launch vehicle.

Both government and commercial ELVs are tracked by these stations during various positions of their launch trajectories. The closing of the NASA station on Ascension Island, however, really only affects McDonnell Douglas' Delta, both commercial and military, and the European Space Agency's Ariane, since there is also an Air Force ground station on the island which services Martin Marietta's Titan and General Dynamics' Atlas. The reason they can be served is their trajectory is somewhat different than the Delta or the Ariane.

However, in another year, the closing of the Dakar ground station will affect all the U.S. launchers. We have not yet assessed the costs of acquiring or building a ground station or changing our telemetry equipment or the other alternatives for these NASA ground stations.

I might point out that there is a tremendous weight penalty impact to make our launch vehicle telemetry system compatible with the TDRSS.

In conclusion, we all want this industry to succeed—members of COMSTAC, the Administration, and the Congress. We need to keep the lines of communication open. There will be a number of unforeseen hurdles over the next couple of years as we get this emerging industry off the ground. Some of the ones mentioned today are just the first few that we have encountered, and they are being worked through COMSTAC.

Last year's industry group of ELV launchers, insurance writers, and brokers, the satellite owners and operators in cooperation with the Congress and the Administration, were successful in getting the Commercial Space Launch Act amendments of 1988 passed in only one year.

The legislation is good, reasonable legislation and represents what can be done when we overcome these adversarial relationships that so often exist between industry and government. I am encouraged by the fact that we have a COMSTAC that can serve as the conduit for the resolution of these problems as they occur.

We recognize that the OCST will be facing increasing workloads in both the licensing and advocacy roles, and we encourage recognition by Congress of budget requirements that are likely to arise as this industry expands.

Thank you very much.

[The prepared statement of Mr. Kehlet follows:]

MR. ALAN B. KEHLET
VICE PRESIDENT AND GENERAL MANAGER
FOR SPACE TRANSPORTATION
MCDONNELL DOUGLAS SPACE SYSTEMS COMPANY

TESTIMONY BEFORE
THE SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES

APRIL 18, 1989

Mr. Chairman, Members of the Space, Science and Applications Subcommittee, I am pleased to be here today to report from the Commercial Space Transportation Advisory Committee or COMSTAC. All of the members of COMSTAC are involved in this emerging commercial launching industry. We are working with the Department of Transportation in order to forge a more viable industry through a more cooperative attitude on both the part of industry and the part of government. We cannot afford the adversarial attitude that exists in a number of other government/industry relationships.

We would also like to commend this committee for its timely passage last year of the Commercial Space Launch Act Amendments of 1988. This legislation helped to remove some of the uncertainty involved in indemnification of a commercial ELV launch, by setting the boundaries of third-party and property risk. For instance, we at McDonnell Douglas Corporation signed an agreement with our customer for a launch approximately three years ago. However, we are still in the process of securing insurance for a launch that is about a month away. This bill will make it easier for the insurance underwriters and, as a consequence, easier for the launchers and the satellite owners and operators to do business.

In recent years, there has been some erosion of America's preeminence in space because of a number of reasons — the Challenger tragedy, fluctuations in our space policies, and the federal budget. We feel that a healthy commercial launch industry can contribute to our world leadership role and, as a result, our international prestige, more domestic jobs, and stronger balance of trade. We are all striving for the same goal: to assure that the United States attains a viable market share in the world market.

I would like to outline some of the areas which may require some attention as we move into this new era for our industry and for this Nation.

COOPERATION BETWEEN GOVERNMENT AND INDUSTRY

As I mentioned earlier, there seems to be an adversarial air that has grown between industry and government. If this emerging industry is to survive, we cannot allow this attitude to interfere. The launch manufacturers need to keep our costs down and our quality and reliability high. Anything that negatively impacts cost, quality or reliability will ultimately make the U.S. less competitive world-wide.

One factor that could contribute to cost reduction is the transition to a uniform commercial launch services approach -- common to both the government and the private sector. While national policy encourages simplification of government contracting practices and encourages the government to procure launch services commercially, there is still a wide gulf between policy and actual implementation, although NASA is proposing to procure "launch services" in its upcoming mixed fleet RFP.

Another way to keep costs down is to build both government and commercial vehicles in a common production line. The advantage to the government is common parts and less cost. If this is done, however, we are required to have government inspection of all vehicles -- whether government or commercial. The disadvantage to the commercial customer can be increased costs for inspections. We are also required to deliver such items as reports which may impose additional costs, but do not assist in management or contribute to quality. The ability of our industry to compete for international market share will be dependent on price, assuming high quality and reliability. Any actions by the Federal government which cause increases in costs will force us to be in a less competitive stance.

ACCESS TO U.S. RANGES BY FOREIGN NATIONALS

Prior to the transfer of NASA ELV launch facilities at Cape Canaveral to the USAF, our industry had dealt with NASA for clearance of foreign nationals — both press and customers. This process usually took 30 days or less for normal clearance and in emergency, 2 or 3 days. However, now that we must work through the Air Force, the process averages about 60 days. The procedure has to be initiated through a foreign national's embassy and involves a lengthy review process by the International Affairs Division of the Air Force.

Our foreign customers have reacted strongly against this change in policy, as you can imagine. They are frustrated and even insulted at this change. We must keep in mind that foreign satellite customers have an increasing range of choices of launch service providers and an important factor for the customer includes user friendly ease of access to his property or satellite.

We at McDonnell Douglas are scheduled to launch the first orbital commercial satellite the end of May and we hope that you all will be able to attend this historic event. Recently, we were informed by the Air Force that all foreign nationals will require an official escort while on the launch site. This event is a major milestone for our industry and for our Nation. We expect foreign press coverage, foreign diplomatic officials, and foreign technicians at this launch. It is a monumental job to get everyone cleared who should be invited.

COMSTAC has initiated a subcommittee to address this issue. The Air Force recognizes the industry concerns and is trying to work with the industry to make the system work a little more effectively for industry. The USAF is also developing a model visit request which is geared to expedite the clearance process. Even if the process is accelerated, the escort requirement is cumbersome and costly. And in case of emergency, an uncleared foreign technical personnel may be denied access to the launch facility.

EXTENSION OF RESTRICTED AREA

Another requirement that was the result of the shift of launch facilities from NASA to the Air Force is an increase in launch security requirements. The security requirement, Wide Area Detection Intrusion System (WADE System), goes into effect 75 hours prior to launch. The WADE System was originally established for DoD classified launches and involves 42 security police stationed around the launch complex, aircraft and helicopter overflights, and Coast Guard protection as well. This contrasts to normal range safety which calls for only 7 security police to set up roadblocks about 24 hours before launch.

The commercial launch cost to engage the WADE System is approximately $250,000 with additional cost of $60,000 per day in the event of launch slippage. The Air Force contends that these costs must be passed on to the launcher because the Air Force is prohibited by law from direct subsidies of commercial launches. However, one of our companies has negotiated a range use agreement which may ease this requirement for them in the future. The concept is yet to be tested, however, and does point out inconsistencies in Air Force application of security requirements.

CHANGE OF TELEMETRY FREQUENCY ASSIGNMENT

Last month the Federal Communications Commission (FCC) issued a Notice for Proposed Rulemaking (NPRM) that would require commercial launchers to use different telemetry bands than the DoD or government bands previously used. Comments from industry were due yesterday to the FCC and we will probably have a regulation finalized by mid-summer. Currently, commercial launchers utilize the 2200 to 2290 MHz DoD frequency for both U.S. Government satellite launches and for private industry satellite launches.

COMSTAC has recently formed a working group, headed by George Koopman, President and CEO of AMROC, to address the potential requirement of the changeover to commercial bands and the appropriate time frame for implementation. If this regulation is implemented, the impact will be to require those commercial vehicles designated in the line as commercial to be outfitted with different telemetry hardware, increasing costs for the commercial launchers. This telemetry is only in operation for about 2 hours for each launch. The current commonality of the transmitters provides for smart logistics and enhances Dod's ability to react to emergency conditions. The use of uncommon transmitters complicates logistics in that spares for both commercial and government launches must be stocked.

We would recommend that the commercial ELVs, especially those where the vehicle is a common carrier for DoD payloads, be allowed continued access to the 2200 to 2290 MHz frequency band.

CLOSING OF NASA GROUND STATIONS

In September 1989, NASA is scheduled to close its ground station on Ascension Island and about a year later, its ground station in Dakar, Senegal. These are closures resulting from having the TDRSS in place for Space Shuttle and will save NASA funding once all the ground stations are closed. While we understand the NASA point of view, we are concerned about the impact now that the ELV industry exists and the shuttle is not the only launch vehicle.

Both Government and commercial ELVs are tracked by these ground stations during various positions of the launch trajectory. The closing of the NASA station on Ascension Island affects only McDonnell Douglas's Delta and ESA's Ariane, since there is also a USAF ground station on the island which services Martin Marietta's Titan and General Dynamics' Atlas. Their trajectory is somewhat different than our Delta or the Ariane. However, in another year, the closing of the Dakar ground station will affect all the U.S. launchers. We have not yet assessed the costs of acquiring or building a ground station, or changing our telemetry equipment or other alternatives for these NASA ground stations.

CONCLUSION

We all want this industry to succeed — members of COMSTAC, the Administration and the Congress. We need to keep the lines of communication open. There will be a number of unforseen hurdles over the next couple of years as we get this nascent industry off the ground. Some of the ones mentioned today are the first few that we have encountered, but they are being worked.

Last year's industry group of ELV launchers, insurance underwriters and brokers, and satellite owners and operators in cooperation with the Congress and the Administration, were successful in getting the Commercial Space Launch Act Amendments of 1988 passed in only one year. The legislation is good, responsible legislation and represents what can be done when we overcome the adversarial relationship that exists so often between industry and government. I am encouraged by the fact that we have a COMSTAC that can serve as the conduit for the resolution of these problems as they occur.

We recognize the OCST will be facing increased workloads in both the licensing and advocacy roles and encourage recognition by Congress of budget requirements that are likely to arise as this industry expands. Thank you for allowing me to testify on this important subject today.

BIOGRAPHICAL SKETCH

Alan B. Kehlet

Alan B. Kehlet was born in Chicago, Illinois on February 8, 1929. He graduated from Joliet Township High School, attended Joliet Junior College (1947), and was graduated from the University of Illinois (BS-Aero Eng. 1951). He received his post graduate degrees from the University of Virginia (MS-Aero. Eng. 1961) and the California State College (MBA 1976). Following graduation from the U of I, he was employed by the National Advisory Committee for Aeronautics (NACA) as a Research Scientist working on the aerodynamics of missiles, airplanes and space vehicles. At the creation of the National Aeronautical and Space Administration (NASA), he was selected as one of the original 35 members of the Space Task Group (later the NASA Johnson Space Center) to design and develop the United States manned space program from Mercury, Gemini and Apollo to the Space Shuttle. In 1962, he was employed by Rockwell International as Apollo Chief Project Engineer to develop the Apollo spacecraft modules.

In 1968, Mr. Kehlet was named Apollo Assistant Program Manager to direct the manufacturing, checkout, launch and recovery of Apollo II, the first Apollo lunar landing mission. At completion of the Apollo II mission, he was named Chief Engineer of the Rockwell Space Shuttle Program. After being instrumental in winning the hardware competition for the Space Shuttle in 1972, he was named Sabreliner Division Chief Engineer to develop and market a new model series of business jet airplanes. The very successful Sabreliner Model 65 (the first transcontinental business jet with advanced aerodynamics and fan jet engines) was certified under his leadership.

In 1978, he was promoted to Executive Vice President of Rockwell's turbo prop airplane division and shortly thereafter was promoted to President of the Sabreliner Division. In 1982, he left Rockwell to become President of the Fairchild Aircraft Company.

Two years later he joined McDonnell Douglas as Vice President of Engineering and Operations of the Astronautics Company. Mr. Kehlet currently holds the position of Vice President General Manager, Space Transportation, where he is responsible for all MDAC unmanned launch vehicles, launch services, and advanced launch systems.

Mr. Kehlet holds patents on the Mercury Space Capsule, a Maneuverable Space Entry Vehicle, and a Parachute Recovery System. He has authored over a dozen published technical reports on airplane aerodynamics and space vehicle designs. His space accomplishments are documented in four NASA publications. He is an Associate Fellow, American Institute of Aeronautics and Astronautics; on the Board of Directors, University of Illinois Alumni Association; President, University of Illinois Department of Aeronautical Engineering Alumni Association; a member of the University of Illinois College of Engineering Advisory Board; and, Assistant Scout Master of the Boy Scouts of America.

Mr. Kehlet is the recipient of many honors including Distinguished Alumnus Award, College of Engineering, University of Illinois; Alumni Achievement Award, Joliet Junior College; elected to Tau Beta Pi, Honorary Engineering Society; NASA Citation for contributions to Project Mercury; and, NASA Certificate of Appreciation for Apollo II Accomplishments.

Mr. Nelson. You mentioned that your insurance is cheaper as a result of this legislation we passed last year.

Mr. Kehlet. Yes, sir.

Mr. Nelson. How much cheaper.

Mr. Kehlet. We were charging the customers about $4 million because we didn't know what it was going to be. I believe the number now is down to less than a million.

Mr. Nelson. That is pretty good.

Mr. Lewis.

Mr. Lewis. Thank you, Mr. Chairman.

I would like to ask Ms. Miller, in your statement, going through the breakout of your budget requirements; for example, on page 7 you are talking about commercial launch operations and ranges, using existing facilities.

These facilities are available. Just tell me, explain just a little bit more what you intend to do in that area. Are we going to reinvent the wheel?

Ms. Lee-Miller. You are talking about the research on the ranges?

Mr. Lewis. Yes, ranges, existing facilities, and operations used by NASA, military. They may not be appropriate, but why wouldn't they be appropriate?

Ms. Lee-Miller. Well, we are looking at a commercial industry here, and in the past the ranges have been working primarily with government launches. So we want to make sure that from a safety point of view, public safety, from the payloads that may be very innovative, that we may be looking at different needs in a brand new industry.

So we are working very hard with the existing ranges, which are very appropriate and have been historically, but we are looking toward the future now, and we are hoping that we will have new and different launches coming up in the future, and we may have to adjust accordingly.

So we want to be on top of the issue in expectation that the industry will continue to grow.

Norm, would you like to elaborate?

Mr. Bowles. Sure.

The problem that we face or the challenge that we face is that if you take a look at the launch operations and the range safety operations that exist down at the government ranges and compare them today with what we had prior to the Commercial Launch Act, maybe 95 percent or more of the operation is now in commercial hands, and that 95 percent was previously managed by the government.

The industry that is down there is a very dynamic industry. We have the three major companies—McDonnell-Douglas, Martin Marietta, and General Dynamics—who are making changes to their vehicles. In addition to that, we have got many new companies introducing new concepts, such as American Rocket Company or Orbital Sciences, Space Services Incorporated, and other companies who are also developing systems that have not yet entered into the public arena, and in addition to that, we also have two states that have expressed a lot of interest in the development of commercial space ports.

Our ability to be able to license these activities, no matter how they may have changed the relationship and the types of things that they handle versus those ranges, is based on our ability to understand what the effects of these changes are.

So this research that focuses on the range operations looks at the effects of new commercial operations on the range safety process, and the other point that should be made is, as Deke pointed out, these ranges do not function as government regulators. They are functioning as contractors to the launch companies. They do not have the ability to understand or control all of the things that they did before.

So this research focuses on that changed relationship. But we do avoid reinventing the wheel.

Mr. LEWIS. Well, I would hope so.

Are you looking at, say, other states like—and working with other states who have proposed space ports or the use of existing launch facilities, such as those at the Cape in Florida, those in the Panhandle of Florida, which are two that I am familiar with? The State of Florida is interested in commercialization and using the space port. How do you interface with the states in these areas?

Ms. LEE-MILLER. Well, we welcome any effort on the part of states to look at their own capabilities within their state for the establishment of commercial ports. We have had inquiries from Hawaii as well, as well as what is going on in Florida, and other states as well.

We see our office operating as a technical assistance arm to assist them in determining whether their state can establish the kind of environment for the launch ranges and for the other needs of the industry and promoting the industry. So we welcome that.

I must say, however, that we do feel our role is one of technical support. It is a state decision, of course, whether they are going to proceed, and we are not presuming to dictate or to interfere with any state necessarily, but we certainly want to promote it as a good will, kind of Chamber of Commerce approach to promoting commercial space ports.

We are hoping we will have a need for increased commercial ports all over the country, wherever feasible, when we can establish those because we expect the industry to grow just that much. We are hopeful, optimistic, and determined.

Mr. LEWIS. That is a pretty expensive industry to grow much.

How do you work interfacing with, for example, McDonnell-Douglas and Mr. Slayton's operation as far as trying to ease the way, so to speak? Do you have that responsibility to work with the Air Force and the problems that Mr. Kehlet brought out in the assignment of telemetry frequencies and things like that? Do you have any opportunity to work with them to sort of "grease the skids" a little bit?

Ms. LEE-MILLER. Absolutely. We see our role as being a coordinating function within the federal government, and when the industry representatives express concerns to us, we want to work to expedite those concerns, to certainly get them on the agenda of other federal agencies that might be involved, the Air Force, NASA, DOD, other parts of DOD.

We are meeting with their staffs constantly, working in a consultant and consultative process, in order to bring the industry concerns to the table and try to work to resolve them where we can.

Mr. LEWIS. Mr. Kehlet, you know, you are no stranger to launch facilities and launching satellites and that sort of thing.

How can the Department of Transportation actually help you to get by some of your problems, those five points that you pointed out? Stay out of the way?

Mr. KEHLET. No, sir. As a matter of fact, we have been quite pleased with what COMSTAC has been able to accomplish so far. I think it affords us an opportunity to meet with other representatives throughout the whole industry. This is not just launch site type people, not just a launch vehicle or satellite; it also is composed of insurance writers and bankers and people like that in COMSTAC. So it represents a wide variety.

I believe that the meetings we have had at COMSTAC and their involvement—we have been working in the Air Force situation now to some extent, and one has to almost go through one of the launches to find out all the problems. It is difficult to prejudge or preconceive what kind of problems you are going to have.

But I think COMSTAC has been very receptive to it, and they have helped us a lot, working with the Air Force. We have to remember the Air Force is our customer.

Mr. LEWIS. That is true.

Mr. Slayton, in your launch at White Sands you dealt with the Army and the Navy, is that correct? You didn't have to deal with the Air Force?

So apparently things moved pretty rapidly for you out there, and you said you did have some interface problems.

Could you explain some of those to us a little bit?

Mr. SLAYTON. Well, I think the big difference—we did a little launch back in 1982, and at that time there was no Department of Transportation Commercial Office. When we came up here, we went through 18 different government agencies independently, and I think the big difference now, we would go straight to the Department of Transportation.

They interface as required, but they are basically taking the lead through the other agencies on our behalf. We still had to go sign our own memorandum of understanding with the Navy. We had to get an individual support agreement with NASA, and we had to work the range safety issues with the Army, but the ground rules had been set and it worked out very nicely. We didn't have any insurmountable problems.

Mr. LEWIS. One last question for Ms. Miller, Mr. Chairman.

How are you going to staff with your technical people in order to be able to interface with all branches of the services and the difference in their modes and still work with the commercial providers?

Ms. LEE-MILLER. So far, so good, Mr. Congressman.

Mr. NELSON. You must be Wonder Woman.

Mr. LEWIS. $4 million is just unbelievable to me for what you have to do.

Ms. LEE-MILLER. Well, as I was responding about the space port issue——

Mr. LEWIS. And I am not a spender.

Ms. **Lee-Miller** [continuing]. We certainly—I appreciate that—we look forward to making sure that the Office develops its procedures in such a way that we don't become cumbersome for industry, number one, as a priority. So we are not looking forward to developing reams and reams of paper and criteria for the licensing process. So we can move quickly.

Right now we feel that we are on top of the caseload as we have it at the current time. However, with the anticipated growth in the industry, the Office will probably have to take a very hard look at its growth as well.

As you have indicated, there is a terrific workload. In the month that I have been in this Office, I have been impressed with the tremendous workload that the staff has been carrying, but they have assured me that to date, with the vacancies we have within the Office and within our budget request, which requests an additional five positions for this year, that we can see our way clear through the end of this fiscal year and on into 1990.

I would like our counsel to further elaborate, if he would, just in terms of what other needs we may be projecting.

Mr. **Musarra**. I guess I would just like to focus very briefly on the point about our interaction with the other agencies.

That has gone extremely well, I think, to date, and in part not just because we have the responsibility of acting as the primary point of contact, but within those other agencies, and I guess I am thinking particularly about the DOD elements that are involved here.

They are working very hard to streamline their network of contacts that we need to have with them and the lines of responsibility that relate to commercial activities, and I think that much progress has been made there, and I think that is certainly a large part of the reason why the process went so smoothly and so quickly, even with the SSI that involved a number of agencies that really were encountering an activity like this for the first time. It was really—there were a number of issues of first impression for them, but they made every effort to deal with them quickly and in an appropriate fashion.

Mr. **Lewis**. Well, I know I am running out of time. I just have a little concern about this because I really believe I want this commercial space program to move.

Let's say that SSI or McDonnell-Douglas contacts the Department of Transportation on a launch contract.

Now, before where Deke said they had to go to 18 agencies, they would go to you.

Now, do you have a project engineer type of individual or project manager type that has the technical background that would work with their people with the same, similar compatible backgrounds so that you can get the job done, or do you use and rely upon the contractors' technical expertise in order to steer you?

Ms. **Lee-Miller**. It is a combination of both, Mr. Lewis.

I am going to ask Norm, the head of our Licensing Division, to answer more fully. However, as an initial process, when the company comes in, the first phase is a mission review, and that is handled very much with staff that we have on board doing a first-cut analysis and augmented, as you indicated, through contracts with other technical assistance from consultants.

But Norm is head of our Licensing Division, and he can answer your question more precisely.

Mr. **Bowles**. Yes. The answer is that we have for each of the launches assigned somebody to act as a project engineer, so to speak. With respect to SSI, that person handled not only the review and the licensing of the launch, they were involved in the inspection process. When SSI needed an emergency exemption for the movement of its launch vehicle, that individual became the primary point of contact with the Research and Special Programs Administration, the Bureau of Hazardous Materials.

The same thing is true for McDonnell-Douglas. We have a—McDonnell-Douglas has a monthly coordinating meeting down at Cape Canaveral with McDonnell-Douglas personnel and range personnel as well as people from our organization, and the purpose of that is to address interagency issues or problems that McDonnell-Douglas has. McDonnell-Douglas, in order to move its launch vehicle from Pueblo, Colorado to the Cape, needed support from some government agency that would send a request to the 12 states that are in between, requesting continuous movement permits, and that individual, that project engineer, took the responsibility for making sure that we got those requests out so that McDonnell-Douglas was able to move its launch vehicle with no difficulty and on time.

So that is the approach that we are taking right now, and we think that is very important because each of these launches has unique problems or unique issues that are confronting it.

So, yes, we do use a project engineer.

Mr. **Lewis**. Well, thank you very much. I do hope, Ms. Miller, that you do project and look to the future because this is just the embryo stages of this industry and it is going to move very rapidly, and I certainly hope that you are able to cope with it and not hold up the program.

Ms. **Lee-Miller**. We are very committed to that.

Mr. **Nelson**. Mr. Packard.

Mr. **Packard**. Thank you, Mr. Chairman.

Ms. Miller certainly has indicated that they feel at DOT that they do have the technical expertise.

Does the industry share that feeling? Are you comfortable with the expertise and competence there?

Mr. **Kehlet**. I believe the answer to that question is "Yes."

Mr. **Packard**. Very good.

Do you think that the private sector, the ELV launch industry itself is ready to move forward and to do much of NASA's and DOD's payload in the commercial manner the same as they have done it—is the commercial private sector ready to move forward?

Mr. **Slayton**. Well, I can only speak for ourselves. We have been ready for about six years, but we do not deal in the big things, but I think in the smaller scale of things, definitely, yes.

Mr. **Packard**. In your judgment, Deke, what has been the impediment in the last six years that you have been waiting and ready?

Mr. **Slayton**. There wasn't a policy till last year that gave the government agencies guidance that said go buy commercial launch services instead of going out and buying your own, and that is just beginning to evolve. We are dealing in a couple of RFPs this week, as a matter of fact, that are going that direction. The launch we did two weeks ago was the first one that was done outside of the NASA environment.

Mr. PACKARD. So last year's legislation you feel has unlocked much of the gates?

Mr. SLAYTON. Yes, sir, precisely. Right.

Mr. PACKARD. How is the procurement process with NASA and DOD, or with DOD and NASA, different from that of the procurement process with the private companies in terms of ELV launches? How do they differ?

Mr. KEHLET. Well, I guess an example I would use is I was in the commercial airplane business, business jets, for a period of almost 10 years, and our commercial contract for a business jet was about three pages long, and the difference I would say is in the thickness of the proposal.

And I don't mean that completely facetiously. The regulations are entirely different. The regulations being imposed on the commercial industry right now are the same ones that are being put on the military. The government procurement practices are slow to change, and I think NASA has made a great step forward with their RFP, but it still is not down to the commercial level that we have seen in the past.

So we are getting there, but basically it is the number of regulations, number of things like measurement systems and reporting systems and the oversight, mandatory inspections, a whole host of things which have grown up over a period of years with military programs that are still being imposed on the commercial industry.

Mr. PACKARD. Do you think that is the primary cause of the differential between costs of private sector launch versus government launch?

Mr. KEHLET. I don't know if it is the prime, but it certainly is one of the large contributors to it.

Mr. PACKARD. Are there other contributing factors, Deke?

Mr. SLAYTON. Yes. I think the little launch we did here a couple of weeks ago is a classic example of one way to do it.

Our contract was with the University of Alabama-Huntsville, purely a commercial contract. We had no interface with NASA relative to that launch except as a provider of services to us.

That money was provided, I believe, some of it at least, by a grant out of NASA to the University of Alabama. So that is one way to escape the piles of government procurement regulations.

Whether you can spend the $50 million launch the same way is an interesting question, but surely there has got to be better ways to do the bigger vehicles, also, along the lines that Mr. Kehlet is talking about, where you buy services. Don't get the government involved in telling you how to design it and build it and check it out. Just tell us what they want, and we will give it to them. Rent it, don't start from scratch is a simple way to approach it.

Mr. PACKARD. Do you think we are coming to the day when the private sector can launch all commercial vehicles or all commercial launch payloads and leave only government and military payloads to NASA?

Mr. **Kehlet**. I would like to interject one comment in here, and I believe again going back to the commercial airplane approach.

The government is involved. There is no question, and I think the involvement of the government in any of these type of launch vehicles is a good thing.

What I think we might be discussing is the magnitude of the involvement and what level, as Deke just pointed out, you go down to.

If the government is paying for it as a customer, they have a right to know what is going on. There is no question about it. Just like commercial people do. So to say that or to even imply, I would not—personally would not like to imply that we are asking the government to get out of the loop. That is not the point at all.

What basically we are talking about is down in the nuts and bolts area that we seem to have the requirement. I think the private sector—commercialization of the space program is like commercialization of the airplanes, and the FAA has done an outstanding job, I believe, in the oversight of commercial airplanes. They don't tell people how to design the airplane, but they certainly have requirements for it and testing requirements that are there.

Mr. **Packard**. One last question, Mr. Chairman, if I may.

In reference to some of the Chairman's discussion relative to foreign competition for launch of American equipment, what, in your judgment, do you think we need to do to keep as much of our own launch business here with our own facilities, within the private sector and the government sector? What needs to be done to keep from exporting this business overseas?

Mr. **Slayton**. I think it is a difficult question because two of the potential competitors are governments, the USSR and China, and it is my opinion they don't know the definition of commercial to start with, and they don't have to do things on a commercial basis. So trying to compete in a commercial program is very, very difficult, and I think, as Chairman Nelson noted, it is going to take some action on the part of the government to get some favored treatment of some kind. They just do not understand.

Why, I have had the Chinese tell me, bring me a price and we guarantee you we will beat it, doesn't matter what it is. I think that is the problem.

Mr. **Packard**. Thank you, Mr. Chairman.

Mr. **Nelson**. Mr. Mineta.

Mr. **Mineta**. Thank you very much, Mr. Chairman.

I am glad to see another Californian who, because of her fine record, gets into a very responsible position at the McDonnell-Douglas. I welcome you into that new position.

Ms. **Lee-Miller**. Thank you.

Mr. **Mineta**. Mr. Kehlet, let me ask, if I might, following up on this whole issue of specifications versus performance standards.

Are we too hung up on specification standards instead of looking at performance standards so that you end up with a long RFP versus a——

Mr. **Kehlet**. Yes, sir.

Mr. **Mineta** [continuing]. And do you think there is anything about our mentality that is going to be able to get us away from that?

Mr. Kehlet. I think it is going to take a lot of careful, logical thought because of the entire environment of government versus industry. It is almost fraud, waste and abuse. The way to control that is to put more regulations, as an example, and that result is that we end up with many, many mandatory inspections, and we all know from past experience that you cannot inspect quality into a product. It has to be built in there, designed in there, and thought about being in there as opposed to any type of regulations, whether it be company or government.

Our industry as a whole has been brought up for so many years with government regulations that even changing the government regulations, it is going to take some time for the companies to change their regulations. We are all a big bureaucracy.

Mr. Mineta. Suppose we changed the emphasis from waste, fraud, and abuse to safety driven. Does that make any difference?

Mr. Kehlet. Yes, it will make some difference, although the safety community will become the "ilities" of the future, and everything——

Mr. Mineta. I am sorry, will become the what of the future?

Mr. Kehlet [continuing]. The "ilities." It will be safety like reliability was, maintainability, where they will become their own cult, and everything will be safety. It doesn't make any difference what it is. The color of the bolts will become a safety issue.

Mr. Mineta. But if we are going to get to the point of having commercial launches and be able to have—now that we have an office that is built to facilitate and to provide the interface between the private launchers and those who may—I mean the private companies and the government sector that may have the facilities, is there some way that we can break down that sort of adversarial relationship, that artificial barrier that seems to exist?

Mr. Kehlet. For my own personal opinion, a closer working relationship to the FAA type of regulations and requirements in the commercial industry would be a good thing.

Mr. Mineta. I wear, or did wear, another hat. For eight years, as you know, Mr. Kehlet, I chaired the Aviation Subcommittee.

Mr. Kehlet. Yes, sir.

Mr. Mineta. And so it is a template, I think, that is there and because it is within the Department—because Ms. Miller's Office is within the DOT it seems to me we do have the ability to maybe get through that. I am quite sure that Secretary Skinner is committed to that, and so I would hope that maybe through the work of this committee, the work of Ms. Miller's Office, and the private sector that we will be able to get to that point of that kind of cooperation.

The thing that bothers me, however, is just within your own testimony. It seems to me we have got NASA giving you a "gotcha" and that is the closing of the ground stations. I mean, that to me, if we are talking about cooperation and then we have NASA just closing something down that affects, as I read what you are saying here, your launches because of your trajectory, I mean to me that is a real "gotcha," and that is not healthy, whether it is you, McDoug or Martin Marietta or GD. Of course, they, I guess, because of their trajectory are in better shape.

Mr. Kehlet. For one year.

Mr. Mineta. For one year.

Well, then what happens—and then they are in the same bag as you are at the end of one year?

Mr. **Kehlet**. Yes. When the station at Dakar is closed, we will lose communications on that site.

Now, there is a subcommittee, as I mentioned before, working this particular situation with NASA. NASA may sell that station. Since Ascension Island, particularly, is owned by the British, they may decide to take over the station and sell it to the Europeans, and we have the choice, if we want tracking, particularly out at Ascension Island, of buying that service at an unknown cost from our competitors, which doesn't make me feel all that good.

But the Dakar station is going to be a problem we just have to work, and we will work it with the NASA.

Mr. **Mineta**. There is no way of buying time or services on TDRSS?

Mr. **Kehlet**. Well, most of the telemetry systems that are used on the launch vehicles are incompatible with the TDRSS frequencies.

Mr. **Mineta**. I see.

Mr. **Kehlet**. And the size and weight and cost, like a million dollars versus 14,000 for telemetry equipment make it just prohibitively expensive.

Mr. **Mineta**. Well, thank you very much, Mr. Kehlet, Mr. Slayton, Ms. Miller.

Ms. **Lee-Miller**. Thank you.

Mr. **Mineta**. Thank you, Mr. Chairman.

Mr. **Nelson**. Mr. Mineta, we know what TDRSS is and RTLS and all those acronyms.

What is a "gotcha"? [Laughter.]

Mr. **Mineta**. I am not sure how to describe it, but I could——

Mr. **Nelson**. You know it when you see it, huh? [Laughter.]

Mr. Rohrabacher.

Mr. **Rohrabacher**. I just would like to note for the record that when Mr. Packard asked if all civilian payloads could be handled by the private sector with the commercial launches that Mr. Slayton was nodding his head "yes," and although the word wasn't uttered, I wanted to note that for the record.

Is that correct?

Mr. **Slayton**. Yes, sir, I agree with what Al was saying about the relationship with the government. We are not proposing to throw the government out. We are just saying that the government is to us a commercial customer, and we would like to be able to treat him like we do all other commercial customers. We are obligated to satisfy them. He has to have oversight in what we are doing just like the rest of our customers, and if we don't make him happy, he won't be a customer very long.

So we are very sensitive to that, but I think, as Mr. Mineta noted, that what we are really searching for here is a concept where you could write a performance spec instead of the hardware spec, and that is where a lot of the problem lies, that people don't quite know how to do that yet.

There was a draft RFP put out last fall for us to look at out of NASA. Well, the labels on it were great, but when you get down into bowels of the thing, it was business as usual. It is just a slow process. I think it is going to happen, but that is what I meant earlier on. Implementation is where the problem lies.

Mr. ROHRABACHER. Some people have been talking about having an enterprise zone in space to encourage the private sector and people looking at space in a different way.

I just would like a general short analysis from each of you in terms of what your view of that idea is. Is that something good? Would that promote space exploration and utilization?

Mr. SLAYTON. I don't know.

Mr. ROHRABACHER. Okay. It is so ill-defined at this point maybe I should wait until I get some more details of what other people have in mind by the whole idea of an enterprise zone in space. It might mean tax incentives for your corporation, for example. It also might mean a totally tax elimination for people who are conducting profit-making operations in space itself, which would encourage people to try profit-making operations in space.

So I guess before I ask you that question I better find out exactly what is being proposed.

One specific question. In the next 10 years we may be involved with retiring entire weapons systems of missiles in the United States. Whether or not we do this because we are updating our missiles or whether it is because we are phasing them out via some negotiated agreement with the Soviet Union, some reduction, can these military missiles that are sitting there now and serving the purpose of deterring nuclear war, could they be put to use—rather than just being destroyed, could they be put to use by companies like your own in putting payloads into space?

Mr. SLAYTON. We have looked at that over the last six years on a number of occasions, and what has happened in the past, not to say it might in the future, every time that we discover something that has been declared surplus by somebody when you start working the details of how you get access to it, it suddenly isn't there any longer.

We have been through it with Minuteman, we have been through it with Polaris, we have been through it with Pershing.

So we do not view war surplus rocket motors as a reliable way to run a commercial business just because they have not been accessible.

The other factor you get into with them, they are generally stacked in a configuration which is optimized for a specific payload. When you take those and try to stack them into something that is commercially viable, you get mismatches, you are involved in a lot of inspection in terms of safety that you don't have to do with new motors, and from a commercial point of view, obviously if you could get them free you might be able to make something useful out of them, but if you are going to pay a fair market value for them we would much rather go buy new motors because they are more reliable.

Mr. ROHRABACHER. I have been noticing that we have been destroying Pershing missiles after a great deal of money has been put into building Pershing missiles.

Mr. SLAYTON. True.

Mr. ROHRABACHER. So you are basically saying that it is an engineering as well as a political problem in terms of access—would be the political problem—that would prevent you from putting these to use?

Mr. SLAYTON. We asked the Army, the Secretary of the Army at one time for permission to use Pershings, and we got it. What happened is by the time we got that permission the IMF Treaty was in place, the production lines were down, and it did not make economic sense.

Whether that would happen with a more modern system I think we would have to wait and see. There probably could be some use made for particular government testing, maybe SDI type things, those sort of things. There has been a lot of that done, where Minuteman stages have been used for suborbital things for testing, and I think that might still be a viable use for some of those.

But we don't view it as a good way to do commercial business.

Mr. KEHLET. I think there is something else, also, and that is that we go three rated systems, the highest being the man rated that we worry about, then the other being, I will say, the unmanned or ELV approach, and then the missiles are probably the least—I wouldn't say reliable, but as far as matching everything together and the engineering requirements and the different mission type of approaches on it, it would cost almost as much to start over again as it would be to use some of those and adapt them.

Mr. ROHRABACHER. And for you, Mr. Kehlet. You mentioned this launch that you are going to be having in May?

Mr. KEHLET. Yes, sir.

Mr. ROHRABACHER. Where is that going to take place?

Mr. KEHLET. We have two launches in May. One is the NavStar 2-2 launch. It will be in early May, and then the last part of May will be our launch of the satellite for India, and they will be at Cape Canaveral.

Mr. ROHRABACHER. And the first, NavStar, would be out of?

Mr. KEHLET. Cape Canaveral.

Mr. ROHRABACHER. Cape Canaveral as well?

All right.

Now, Stephanie, just godspeed, and you know that all of us on this committee are going to be trying to work with you as much as possible, and we wish you the very best of luck.

Ms. LEE-MILLER. Thank you very much.

Just as a commercial, the second launch he referred to is licensed by the Office of Commercial Space Transportation.

Mr. KEHLET. As a matter of fact, that was your first commercial license.

Ms. LEE-MILLER. Yes. I want to make sure that that goes on the record.

Mr. Congressman, you mentioned this enterprise zone in space concept. I don't want to venture any analysis, not understanding it well myself, but I think one of the objectives we have for the Office of Commercial Space Transportation is to really spark dialogue and new ideas and innovation. We want to reach out to the youth of America in particular and get them involved in the dialogue, and guys like Deke Slayton who are real pioneers in this area, we want to find a whole army of Deke Slaytons somewhere in the heartland of America that can really come forward with innovative approaches, because that is what is going to make the cutting edge for American business in competition both domestically and abroad.

Mr. ROHRABACHER. Thank you.

Mr. NELSON. Deke, NASA is putting out a small launcher, small launch services procurement letter later this summer.

Do you want to, for the record, state any guidance that you would give NASA as they go about doing this?

Mr. SLAYTON. Yes, sir, we have looked at the medium launch vehicle, one which is on the street now, and I think if I was going to modify that along the lines that we would prefer to see it would be along the lines that Mr. Mineta talked about, to make it more performance oriented, make the specifications—tell us what you want as an end-product; don't tell us how to build it down to the last nut and bolt.

I think that would be the main thing I would suggest to them.

We recognize NASA has a right to intervene in our activities to the extent of FRRs, design reviews, those things. We welcome all of that, but we don't need them to tell us how to do it, and NASA has a lot of people—and I used to be one of them—that delight in telling people how to do things. It takes a little different change in culture.

But I think one thing is important when you look at the difference between commercial and typical government. I think that government should have a concern with safety. Whether or not something fails, is guaranteed to fail or not to fail may in the commercial world not be so important. The issue is that it fails safely.

You can envision scenarios where you can blow up two out of three and still make a business if you can build them cheap enough. So the secret is when they fail, they fail, they are guaranteed not to hurt anything.

Mr. Mineta.

Mr. MINETA. In the FAA we have these designated engineering representatives.

Is that a concept we maybe ought to consider in the Office of Commercial Space Transportation?

Mr. KEHLET. Not only the DERs, but the DMIRs, which are the designated manufacturing inspection representatives.

I personally think it is a good concept. We all fly on airplanes, and those airplanes are approved. All the drawings are approved. The inspection processes are approved by these DERs and DMIRs, which are FAA-designated representatives of the contractor.

Generally, you find in the engineering department the supervisor that signs off the drawings, signs off as both the contractor and the DER, and I think it is a very good concept.

Mr. MINETA. Thank you, Mr. Chairman.

Mr. NELSON. Mr. Kehlet, do you think that there might be something of value for us to encourage NASA to come up with some kind of model kind of launch vehicle procurement document so that you would avoid these—where you have got a fixed price contract that you don't need certified cost and pricing data for all that? What is your comment there?

Mr. KEHLET. Well, I think the RFP on the mixed fleet was a major step forward. One of the concerns, I believe, being an ex-

NASA guy like Deke—in fact, Deke and I worked together on Mercury—is that the NASA is subject to regulations, also.

I believe that under present law NASA must invoke the FARs as they stand right now, and I think that may be an impediment to NASA really getting down to a commercial volume.

Mr. NELSON. Well, the RFP to which you refer, was that for the acquisition—you are talking about the Air Force RFP for medium launch vehicles?

Mr. KEHLET. No, sir.

Mr. NELSON. You are talking about for the acquisition of launch services?

Mr. KEHLET. I am talking about the acquisition for the NASA mixed fleet.

Mr. NELSON. All right, and you are saying you are happy with it?

Mr. KEHLET. I think it is a step forward, yes, from what it used to be.

Mr. NELSON. Well, that is what threw me because that is not what—you know, you are dressing it up right now, is what you are saying? A step forward. That is not what your statement says.

Mr. KEHLET. I think that we all had opportunities to talk to NASA during the draft RFP and the question and answer session they had, and we made our comments, and this is the RFP that is out in the street right now.

Mr. NELSON. Well, you are still talking in code to me.

We are going to give NASA some direction as a result of this hearing.

Now, why don't you state what you think could be an improvement in this medium launch vehicle procurement?

Mr. KEHLET. I think what Deke Slayton stated; that is, describe requirements as opposed to "how to."

But I must repeat again, I believe NASA tried this initially and then got stuck with the FARs that they are required to obey.

Mr. MINETA. Mr. Chairman, again maybe NASA isn't the one that ought to be doing that because their mentality is this long experience they have, which is something we ought to draw on. But maybe they are not capable of really making the kind of drastic change or turn that is expected in terms of how we look at doing something differently.

Suppose that were in Ms. Miller's shop instead of at NASA. Would there be a difference?

Mr. SLAYTON. I think there are people in NASA that subscribe to what we are all saying here, and a number of them. I think the problem is like any government—

Mr. MINETA. Can you get them out of the closet?

Mr. SLAYTON. Well, some of them are, but, you know, like any big government agency, you don't get one voice, and this is going through the growing pains, I think, and with a new Administrator just coming on board and some high level management changes, I am optimistic that they will wind up doing the right things sooner or later.

Mr. MINETA. Thank you, Mr. Chairman.

Mr. NELSON. Mr. Stallings, you any time hop in here.

Ms. Miller, do you have any additional comments about the bill that we passed last year into law for any further clarification or modification that you would want to see?

Ms. Lee-Miller. I am going to ask Gerald to elaborate because he has been chiefly responsible for implementing the amendments, but from my observations of them so far they seem to be very clear, and they seem to have been a great aid to the Office and to the commercial launch industry in clarifying the insurance requirements for the launches.

Also, the provision to require the scheduling study has forced the Office to really pull together some data for purposes of reporting back to you shortly. That we also think would be very useful.

Gerald, would you like to elaborate on perhaps areas in addition?

Mr. Musarra. Mr. Chairman, I can't think of anything right now that I would want to identify as any major issue or problem that we have.

I think that our experience with the amendments has been one that has been tough in some ways in that the matters that are the subject of the amendments are very complex and, similarly, just making decisions concerning implementation involves many complex issues. But we are very, very mindful of what the objectives were there, to protect the various parties that are involved in these activities, but to facilitate this industry at the same time, and we are certainly determined to see that our implementation fully achieves those objectives.

Mr. Nelson. Mr. Mineta, before you leave, one of the things that we might do is sometime in the next few days let's get together and let's talk about what we could do with regard to both NASA and the Air Force. There was some testimony here that there is still the bureaucratic foot-dragging, which was part of the reason for our bill last year, to try to streamline it to enable these guys to get moving.

Now, you know on other kinds of testimony, closing ground stations may be a problem to you, but it is not as if you didn't know well in advance. I mean, that has been the whole purpose of the TDRSS system, and so forth, is try to hold down costs by closing ground stations so that we—now, there might be other reasons that we need backups, and so forth, in the operation of NASA and the Space Shuttle, and so on and so on, that we want to reconsider that. But just for the convenience of the commercial operators, it certainly isn't as if you didn't know that the ground stations were going to be closed because that is the system we have been going toward for some period of time.

I will get with you, Norman, on that.

All right. We just simply, as a subcommittee, want to invite any industry represented here today to comment on how to move toward a better commercial environment for launch services procurements. There is simply no excuse for NASA to continue its foot-dragging or for the Air Force in the matter. We have seen procurement innovations taken in the Air Force in how we have seen the implementation of this legislation, and it is time for NASA to break out of its bureaucratic mold and be a little more innovative, and so this committee, I can just tell you, is going to continue to address this issue, and if we have to, we will do it in the NASA authorization bill.

And I understand the delicacy, Mr. Kehlet, of your position.

Mr. **KEHLET**. Thank you.

Mr. **NELSON**. You don't want to openly criticize them because you have to deal daily with them, but, you know, we got to get the comment from you guys.

Mr. **KEHLET**. I would like to make one more comment. You asked about legislation.

In the bill there is a sunset provision. You might consider that provision as to whether it requires a sunset or what.

Mr. **NELSON**. And are you suggesting we perhaps consider a sunset provision on NASA, also?

Mr. **KEHLET**. No, I am not saying that.

Mr. **NELSON**. You are talking about the Commercial Launch Services Act.

Mr. **KEHLET**. Yes.

Mr. **NELSON**. Okay.

All right, anything else from the committee? Mr. Stallings? Mr. Walker?

Ah, Mr. Walker, our commercial expert. We welcome you back.

Mr. **WALKER**. Thank you, Mr. Chairman.

Mr. **NELSON**. You have ascended to such lofty heights that it is an honor to have you come back.

Mr. **WALKER**. Well, thank you, and it is nice to be here. I am sure that you have given these people an adequate hearing. I just wanted to make certain that we were continuing to move forward the commercial side of space, and some of the folks here, including our friend Deke, need to be congratulated on the first successful launch, which I am sure that we were able to do in the course of the hearing today because there is an exciting new era ahead with the commercial community making a vital contribution to our space future.

I am glad you held the hearing. It is nice to be with you, if only briefly.

Mr. **NELSON**. Well, Mr. Walker of course was tremendously helpful as we put together this legislation under difficult circumstances. At one point we had the threat of a veto because we were not going to completely revamp the entire tort system of the United States, and so that is what we had to battle throughout this.

And my earlier remarks are that the proof is in the pudding. We have 26 signed commercial launches, many of whom spurted and came to fruition as a result not even of the act being signed, but while we were—and they knew it was on a serious legislative track under consideration last year, and 26 signed up between now and early 1992. So it is on its way. Now, we are trying to figure out how to make it better.

All right, thank you and have a good afternoon. The meeting is adjourned.

[Whereupon, at 3:27 p.m., the subcommittee was adjourned.]

APPENDIX 1

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

JUN [illegible] 1989

Reply to Attn of: XC:MDD:01117f

Ms. Susan Dumay
Hearing Coordinator
Subcommittee on Space Science
and Applications
Committee on Science, Space
and Technology
House of Representatives
Washington, DC 20515

Dear Ms. Dumay:

Enclosed are the final responses to written questions resulting from the February 28, 1989, hearing at which Mr. Odom testified on the FY 1990 Space Station budget request.

This material completes the information requested during this hearing.

Sincerely,

Mary D. Kerwin
Director, Congressional Liaison Division

Enclosures

Responses to Written Question Submitted by Chrm. Nelson.

QUESTION 1:

Provide a comparison of the schedule for major milestones (including PDR, CDR, first element launch, permanent manned capability, complete assembly, phase II) projected with the FY 1989 budget submission relative to the current (March 1989) estimate. Where possible, indicate the month the milestones will occur.

ANSWER 1:

	FY 1990 Submit - (current)	FY 1989 Update (April 1988)	FY 1989 Submit (January 1988)
PDR	3rdQ90-3Q91	3rdQ89	3rdQ89
CDR	2ndQ92-3Q93	2ndQ91-4thQ92	2nd Q91-4Q92
FEL	1Q95	1Q95	1Q95
MTC	4Q95	4Q95	1Q96
PMC	4Q96	4Q96	4Q96
AC	1Q98	1Q98	1Q98

QUESTION 2:

How much additional schedule slip could be anticipated if Station funding were, for instance, cut 10 percent in FY 1990? 20 percent in FY 1990?

ANSWER 2:

NASA recently completed an exercise to assess the potential impact of a $400 million cut (roughly 20 percent) in the Space Station's FY 1990 budget, with a proportionate cut in FY 1991. If program content were maintained in this scenario, the program would slip nine to twelve months.

A delay of this magnitude would disrupt the momentum that has been built over the last five years with great effort, both here and abroad. The Space Station's valuable benefits for research, technology development, applications, and research, technology development, applications, and exploration would be postponed, and the inefficiencies resulting from replanning and rescheduling would cause a net increase in program costs international partners would be adversely affected, which could call into question the strength of our commitment to the Space Station program and the reliability of the U.S. as a partner in international endeavors.

QUESTION 3:

In the FY 1989 Authorization Act and accompanying report, the Committee asked for reports including: 1) to detail the methodology for proposed life cycle costing analysis of the station and 2) the advisability of designing and constructing a docking mechanism (using metrics) compatible with other stations and vehicles. When will these reports be available?

ANSWER 3:

The design-to-life-cycle-cost process report will be available prior to PDR (second quarter of 1990), in accordance with the requirement in the FY 1989 Authorization Act (P.L. 100-685). This Act also requires NASA to submit a report on the status of the assessment for an International Space Docking Working Group by May 17, 1989. NASA's report is complete and Interagency concurrence is pending. The report will be submitted in the near future.

QUESTION 4:

A new start in the space station budget is for a ground radar to study orbital debris. When will there be preliminary measurements available and can they affect station design or deployment and what is the potential for cost sharing the radar with other agencies or foreign governments?

ANSWER 4:

Preliminary measurements from the orbital debris radar will be available in the summer of 1991. The data are needed before the space station Critical Design Review (CDR), which is currently scheduled to begin in the second quarter of 1992. If the measurements show that the debris threat exceeds current estimates and safety margins, then the shielding design may have to be modified.

We are exploring various options with the DOD, including having them conduct the long-term operation of the radar. However, DOD interests are currently unclear. As for possible cost-sharing with foreign governments, the legal and financial difficulties inherent in exchanging funds between agencies of different governments are such that NASA's policies have always ruled against this. All international cooperation occurs on a "no-exchange-of-funds" basis, with each side responsible for the costs of fulfilling its agreed-upon responsibilities. Further, there are no foreign facilities of which we are aware that are capable of conducting the required mission.

QUESTION 5:

Please provide your analysis of the near-term personnel problem facing NASA's Space Station effort in terms of recruitment and retention of skilled workers; including the causes of and solutions to this problem?

ANSWER 5:

Fiscal years 1989 and 1990 are crucial for the Space Station Freedom Program because preliminary design of all major elements is in progress. This significant activity cannot be properly performed without adequate staffing, particularly in the system engineering and integration function.

Several factors contribute to the staffing problem at the Program Office in Reston, Virginia:

- Competition for skilled system engineers in a high tech area (Reston Tysons Corner, Dulles Corridor)
- Low government salary levels, combined with the high cost of living in the Washington area, make it difficult to recruit from other NASA installations and from the private sector. (For example, only 5% of the personnel at Level B (Houston) moved permanently to Level II in Reston. Furthermore, a high percentage of qualified applicants have declined positions in Reston because the salary is insufficient.)
- A 6-12 month lag between tentative selections and official position offers (due to extremely low or flat hiring rates caused by insufficient budget authority) makes it difficult to keep qualified applicants interested.

It is imperative that an adequate number of skilled system engineers be hired at the Program Office as soon as possible to ensure that the program can remain on schedule. In the short term, NASA is making every effort to attract and retain a skill mix that balances younger and mid-level system engineers with more senior system engineers. We are also exploring some form of locality-based pay (limited to the Washington area) for scientists and engineers. Longer term solutions include:

- An alternative pay system for NASA (being studied by NASA and OPM)
- Budget authority stability which would allow the program to staff in a more systematic manner.

QUESTION 6:

When will a decision be made on the configuration of the CERV vehicle and will it be part of the baseline?

ANSWER 6:

NASA plans to issue a request for proposals for phase A prime/B definition of the CERV in early summer and make a selection by late summer; the requirements cannot be determined before this work is complete. If a CERV development is required, an FY 1992 new start would be necessary to assure its availability by permanently manned capability in 1996.

QUESTION 7:

Could you provide NASA's estimated costs of the proposed commercial initiatives (both FY 1990 and run-out) as well as estimated government costs if facilities are leased?

ANSWER 7:

The estimated costs of the proposed commercial initiatives if NASA was to bear the total cost are:
($ in millions)

Development	FY 90	Budget to Completion	Total
Neutral Buoyancy Laboratory (NBL)	30.0		30.0
SS Processing Facility (SSPF)	43.0	40.7	83.7

Requests for Proposals are being prepared to solicit proposals from the private sector for actual lease estimates for these facilities.

APPENDIX 2

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of XC:MDD:00892f

MAY 31 1989

Ms. Susan Dumay
Hearing Coordinator
Subcommittee on Space Science
and Applications
Committee on Science, Space
and Technology
House of Representatives
Washington, DC 20515

Dear Ms. Dumay:

Enclosed are the final responses to written questions submitted by Chrm. Nelson and Cong. Brown resulting from the March 1, 1989, hearing at which Dr. Fisk testified.

This material completes the information requested during that hearing.

Sincerely,

Mary D. Kerwin
Director, Congressional Liaison Division

Enclosures

Responses to Written Questions Submitted by Chrm. Nelson.

QUESTION 1:

The runout for the 1990 budget increases by $165 million in FY 1991 and $225 million in FY 1992. These represent 8.3 and 10.6 percent increases over the previous years. What portion of each increase represents inflation? When is the "bow wave" projected to disappear?

ANSWER 1:

The current level of funding set forth in the FY 1990 budget is the bare minimum necessary to maintain a vital and productive space science program, particularly in this year of such an intense space science flight rate. The future increases in the Office of Space Science and Applications (OSSA) budget are due mainly to the Shuttle's return to flight and the subsequent increase in previously approved spacecraft development and launch opportunities. OSSA has manifested twelve flights in FY 1990 and 1991, with the need for increased data collection and analysis capability associated with these missions. The OSSA budget in subsequent years includes the funding necessary to complete the development efforts of previously approved spacecraft missions and to conduct the essential mission operations and data analysis activities associated with the launches of these projects.

QUESTION 2:

If Congress restores funding for ACTS, how many ground stations do you expect to build?

ANSWER 2:

Within the Congressionally mandated ceiling of $499 million for ACTS, NASA is building three ground stations to be ready for systems tests in 1991 and operation with the ACTS spacecraft in 1992: a Master Control Station in Cleveland, Ohio; a Link Evaluation Terminal (closed loop), also in Cleveland, and a communications terminal with a 24-voice circuit capacity. The communications terminal is a prototype intended to be used as a model for the industry provided experimenter terminals: Comsat has committed to build one of these communications terminals, and GE has committed to build two similar terminals.

QUESTION 3:

What funds will NASA be committing for the establishment of new data centers over the next five years for Planetary science, astronomy/physics and earth science? How much will be budgeted in these three categories to maintain these new data centers as well as existing data centers?

ANSWER 3:

OSSA employs a unified, but distributed approach to assure the orderly flow of data into archives to be available to the general research community and to preserve it for long-term use. The National Space Science Data Center (NSSDC) serves as a central archive facility and also works in close concert with the science discipline programs to maintain the overall architecture, policies, procedures, interface standards, etc., to coordinate and integrate the data systems developed and operated by the various disciplines. These data systems are in turn distributed with a variety of nodes providing value-added products, services, and analysis capabilities, as driven by particular needs of that discipline community.

In the Physics and Astronomy budget, approximately $50 million will be spent over the next five years towards continuing activities at existing data centers, including activities at the Space Telescope Science Institute. Approximately $30 million over the next five years will be committed to new data centers, in support of missions including the Extreme Ultraviolet Explorer, the Gamma Ray Observatory, and the Advanced X-Ray Astrophysics Facility.

In Planetary Science, approximately $20 million is budgeted over the next five years for new data center activity.

In Earth Science and Applications, approximately $100 to $125 million is budgeted over the next five years for existing data center activity. In addition, the Communications and Information Systems Division in OSSA has budgeted approximately $175 to $200 million to support the Earth Science and Applications' and other division's existing data center activity.

QUESTION 4:

When will NASA have a complete directory or catalogue of all archived space science data?

ANSWER 4:

The National Space Science Data Center (NSSDC) currently has a complete hard-copy catalogue of archived space science data. The NASA Master Directory System, developed by the NSSDC is an automated, on-line system which provides summary information about NASA data sets, their applications, locations, and the ability to link to other NASA data systems for more detailed information. The NSSDC and the discipline data systems work together to catalog the data, store it, and provide information about it via the Master Directory. While automating every extant space science data set may take a number of years, the directory of the basic archive of data (from the National Space Science Data Center and larger divisions within the Office of Space Science and Applications) will be available on-line sometime in the summer or fall of 1990, and will contain 90-95 percent of all available data. The directory system itself is completed and functioning; data set descriptions now need to be entered into the system.

QUESTION 5:

What will be the budget in 1990 and 1991 to support research using archived data?

ANSWER 5:

The use of archived data for research is supported primarily through Research and Analysis (R&A) budgets. The R&A budgets also support theoretical studies and numerical modeling, suborbital observations, laboratory and ground-based investigations, and advanced technology development in addition to archival data analysis. For example, research using archived data contributed significantly to the realization of ozone depletion in the Antarctic. Furthermore, researchers often pursue their work using some combination of these activities rather than constraining their efforts to a single activity such as analysis of archived data. Consequently, the budget for supporting research using archived data can only be estimated. A reasonable estimate is that 35 percent of the total R&A budget will be used to support archival data analysis. For FY 1990, the figure is approximately $170 million.

QUESTION 6:

What will be the budget for Principal Investigators for Astronomy and Physics, Planetary science, and Earth Science (separately) in FY 1990 and FY 1991?

ANSWER 6:

The estimated funding for science research investigations is approximately $195 million per year for Astronomy and Physics, $170 million per year for Earth Science, and $120 million per year for Planetary science.

QUESTION 7:

How many principal investigators and guest investigators are currently supported by NASA grants?

ANSWER 7:

It is estimated that approximately 4500 investigators are supported by the Office of Space Science and Applications funding.

QUESTION 8:

The production of Physics and Astronomy Ph.D.s for U.S. citizens is declining. Does NASA anticipate a shortfall of scientists in the coming decade? Is NASA monitoring trends in the supply of Ph.D.s and, if so, how is this being done?

ANSWER 8:

Yes. NASA, and particularly the Office of Space Science and Applications, is very concerned about the trend toward declining numbers of science Ph.D.s in this country. NASA is monitoring the trend through close contact with the university community via advisory committees, educational organizations (e.g., the Association of American Universities, the National Council of University Research Administrators, and the University Space Research Association). The National Research Council is also monitoring demographic trends of NASA-funded investigators and graduate students in the Resident Research Associateship Program. Currently 50 percent of the overall participants are foreign nationals; the percentage of foreign nationals in the engineering groups is considerably higher.

The Joint University Venture (JOVE) initiative is a new pilot program designed to address this problem: it is intended to broaden the participation of university scientists in the space program, and at the same time spread the excitement of the space program to many more students at universities as well as the secondary and elementary school levels.

QUESTION 9:

Please provide a detailed explanation of the following program reductions and their effects:

- o $25 million for CRRES ELV mission
- o $5 million for payload support in P&A
- o $10 million CRAF/Cassini

There are no funds in the magnitude of $25 million presently included in the OSSA budget for a CRRES ELV mission. The present OSSA budget only provides funding for chemical canisters and data analysis support. CRRES is being developed by NASA for the Air Force on a reimbursable basis and is scheduled for launch on an Atlas-Centaur in 1990.

A $5 million decrease in payload support for physics and astronomy would affect the preparation of shuttle payload instrumentation for flight, i.e., integration and testing. Manifest changes and increased STS requirements since the FY 1990 budget was prepared have already depleted the small amount of management-flexibility in this line item. A trade-off between deleting a payload mission versus slipping a set of OSSA missions would need to be reviewed. A delay or deletion of a mission would further impact shuttle operations. Alternative payloads would need to be identified to fill these flights. Such an approach could potentially increase the costs of other programs accelerated to meet a new flight opportunity.

A $10 million reduction to CRAF-Cassini would place untenable risk on spacecraft definition and design efforts in the initial stages of development, especially considering the reductions made as a result of the budget negotiations within the Administration.

QUESTION 10:

If the OSSA budget is cut by another $100 million before the end of this year, which programs would be cut or descoped?

ANSWER 10:

Another $100 million cut to the OSSA budget this year would require that we terminate some science discipline. Complete cuts, not just rephasings, would occur. Doing so would delay the targeted missions, causing greater out-year total development costs and problems in our commitments to our international partners. The particular areas to be eliminated would be determined using the OSSA Strategic Plan as a guide.

QUESTION 11:

Does NASA intend to develop a Strategic Plan for Space Applications in the same way that NASA established such a plan for Space Science? If so, when will this plan be available?

ANSWER 11:

The OSSA Strategic Plan is a plan for science and applications. It includes attention to the long range applications objectives in Earth remote sensing, microgravity and life science research, and space communications technology. Other applications programs are managed by the Office of Commercial Programs.

QUESTION 12:

Have you completed your study of the environmental impact of the Radioisotope Thermal Generators (RTGs) on Galileo? What is the risk?

ANSWER 12:

The environmental impact study of the Radioisotope Thermal Generators (RTGs) on Galileo was sent to the Environmental Protection Agency (EPA) on May 26, 1989, and we expect release in early June. At this time it appears that any risk of adverse environmental impacts are extremely remote.

QUESTION 13:

Why was the first of the Earth Probes dropped from the FY 1990 budget?

ANSWER 13:

Budget constraints precluded us from including Earth Probes as a proposed new start in the FY 1990 budget. However, we are continuing to support definition studies for future Earth Probes, with plans for possible flight of a Total Ozone Mapping Spectrometer (TOMS) on the Soviet Meteor-3 spacecraft. OSSA also recently selected a preliminary TOMS proposal in the Small Explorer competition.

QUESTION 14:

The ozone measuring sensor (TOMS) on Nimbus-7 may fail at any time. What other methods are available to obtain this critical data and how soon can they be in place?

ANSWER 14:

Launched in 1978, the design life of the TOMS aboard the Nimbus-7 was originally planned to be one year. Although currently still functioning, it is likely to fail sometime this year. There are a number of plans currently being considered to replace this important source of ozone data. OSSA plans to launch a TOMS aboard the Soviet Meteor-3 in 1991, and four of the ten instruments on UARS to be launched in 1991 will measure ozone. The TOMS small explorer is targeted for a FY 1993 launch. The Solar Backscatter Ultraviolet Radiometer (SBUV) to be launched on a NOAA satellite in the near term measures profiles of ozone (not total ozone), but will still provide us with important ozone information. Finally, the U.S. is currently conducting negotiations with Japan to fly a TOMS on their ADEOS mission, which is planned to be launched in February 1995.

QUESTION 15:

NASA achieved considerable cost savings by utilizing the same spacecraft design for CRAF and Cassini. Mission to Planet Earth involves a number of platforms. Could NASA save money by applying this principle of shared design for the Mission to Planet Earth?

ANSWER 15:

It is important to note that Mission to Planet Earth is only a concept in the preliminary stages of study and definition. The proposed Earth Observing System (Eos) is the major component of the Mission to Planet Earth concept. The Office of Space Station is responsible for providing the U.S. polar platforms which Eos will use, and the current configuration calls for using the same design for each platform. Therefore, the experiments which the Office of Space Science and Applications is planning to fly aboard the platforms will be configured similarly in terms of attach points to the platforms.

QUESTION 16:

Reductions have been made in the scope of Mission Operations and Data Analysis for the Mars Observer, and yet the cost estimates for MO&DA have doubled. Why?

ANSWER 16:

The current MO&DA budget for Mars Observer is a product of a series of baseline reviews of revised mission operations and science requirements reflecting the mission replanning, which incorporates changes in the launch date and launch vehicle configuration. This plan utilizes a lower cost approach to operations by involving the use of a multi-mission control team and remotely-located science users.

Approximately one-half of the increased costs represent the FY 1995 funding required to complete the baseline mapping mission. Without this funding, approximately five of the planned eleven mapping cycles could be completed. The balance provides for the post-mission analysis of the data required to maximize the overall science return of the mission.

QUESTION 17:

What is the current schedule for completion of the 1.8 Meter Centrifuge and what is the earliest date that it can be launched?

ANSWER 17:

The 1.8 Meter Centrifuge is scheduled for a test and check out of the equipment aboard the Space Life Sciences Lab-4 (SLS-4), currently manifested to fly in June 1994. The full mission, including animals and science data gathering, is currently planned for SLS-5, to be launched in January 1996.

Written Questions Submitted by Cong. Brown

QUESTION 1:

We understand that OSSA is considering the submission of an FY 1991 new start for a Reusable Reentry Satellite (RRS) program. Given the capability of the RRS to support the flight requirements of both life science and materials science investigators, to what extent will this new start reflect the flight requirements of both life science and materials science investigators?

ANSWER 1:

The Reusable Reentry Satellite concept is currently being studied for Lifesat, a potential small mission program in the Life Sciences Division of the Office of Space Science and Applications. To date, specific requirements have been developed in the areas of Radiation Biology and Gravitational Biology Payload modules to support rodents, plants, and general and cellular biology. Material Sciences requirements are still evolving, and a Reusable Reentry Satellite appears promising for certain applications. Power and upmass constraints of Lifesat limit its suitability for material sciences experiments to high priority protein crystal growth investigations.

QUESTION 2:

I (George Brown) have long been a champion of stimulating the civilian application for aerospace technology developed in support of the Department of Defense (DoD). One example brought to my attention by Dick Delauer of the Space Applications Board is NASA's proposed Reusable Reentry Satellite, or Lifesat. As Lifesat can trace its heritage back to the Satellite Reentry Vehicle (or Discoverer) technology developed in the late 1950's by DoD, please provide the committee with a summary of how Lifesat can exploit the technology developed under the SRV/Discoverer program and any relevant cost savings.

ANSWER 2:

The Department of Defense supported the development of the classified Space Recovery Vehicle (SRV), known as Discoverer, through private industry during the early 1960's. Versions of the vehicle in different sizes and capabilities were developed. The SRV was retrieved by an "in the air" catch bv aircraft over water; water recovery was used as a backup. Terminal descent of the SRV was by fixed parachute. Over 500 missions were accomplished throughout 1960 and 1970.

Recovery of the vehicle and a part of the payload is a significant factor in the use of unmanned spacecraft. The Discoverer was designed for this purpose and has a proven capability. The use of SRV technology for Lifesat will be primarily a scaling situation from the sizes used by DoD. The controlling factor for the overall size of a SRV and thus its payload handling capability is its diameter. Diameters in the 30 to 50 inch range have been used in the past. Initial concepts of Lifesat indicate that a diameter in the 10 inch range will be required to provide an adequate payload for Life Sciences in the range of 300 to 500 pounds and an overall launch mass of 2500 pounds.

Specific technologies from the SRV that are directly transferable to Lifesat are: thermal control (passive), entry heat shield (ablative), flight dynamics and control, attitude control, entry initiation and control, landing dispersion and recovery, and refurbishment/reuse.

The major new technology to be included with Lifesat is replacing the previously used fixed parachute with a controllable parachute or ram glider wing to facilitate precise land landings. Several promising techniques are under study.

APPENDIX 3

NASA

National Aeronautics and
Space Administration

Washington, D.C
20546

JUN 19 [illegible]

Reply to Attn of XC:MDD:01116f

Ms. Susan Dumay
Hearing Coordinator
Subcommittee on Space Science
and Applications
Committee on Science, Space
and Technology
House of Representatives
Washington, DC 20515

Dear Ms. Dumay:

Enclosed are the final responses to written questions submitted by Chrm. Nelson resulting from the March 7, 1989, hearing at which Mr. Aller testified on the FY 1990 space operations budget request.

This material completes the information requested during that hearing.

Sincerely,

Mary D. Kerwin

Mary D. Kerwin
Director, Congressional Liaison Division

Enclosures

Responses to Written Questions Submitted by Chrm. Nelson.

QUESTION 1:

What are the modifications currently being done to improve the reliability of the White Sands computers?

ANSWER 1:

We are attempting to minimize any hardware changes to White Sands Ground Terminal until we eventually upgrade the facility to be compatible with the new, more reliable architecture used at the Second TDRSS Ground Terminal (STGT). Limited software upgrades have occurred to the traffic control computer and the user service computer interface to a Local Area Network (LAN). These are in a final testing phase.

QUESTION 2:

How many hours per week is the TDRSS system down because of scheduled and unscheduled maintenance at the current White Sands Terminal?

ANSWER 2:

Four hours per week of TDRSS system downtime are scheduled for maintenance. Approximately eight hours per month of downtime are scheduled for software delivery and on-line testing. Unscheduled maintenance is unpredictable and usually caused by hardware failures and software problems. The hardware failures cause service outages ranging from several minutes up to 120 minutes. Software problems with the central computer cause total system outages ranging from 25 to 40 minutes.

QUESTION 3:

What will be the projected hours per week TDRSS will be needed to support future missions including the Space Station?

ANSWER 3:

TDRSS will be needed continuously to support future missions including Space Station Freedom. An estimate for single access usage shows a need for 770 hours per week and a multiple access need for 820 hours per week in 1997. The single access demand cannot be supported without the launch and deployment of a fourth TDRSS satellite and the additional ground capability provided by the Second TDRSS Ground Terminal (STGT).

QUESTION 4:

Please provide the quantitative risk assessments or other analysis done to determine whether Hawaii and/or Ascension Island are needed to support future missions.

ANSWER 4:

In December 1988, the Office of Space Operations requested that Goddard Space Flight Center identify any changes in operational requirements that occurred since the initial assessment and decision to close the stations and to assess the risks of closure for each flight project. Goddard responded in January 1989 indicating their spacecraft either had no need for the ground network for emergency support or could, with minimal risk, use the remaining stations for this purpose. A "worse-case analysis" with regard to orbital position was performed on the COBE, UARS, GRO, and HST to determine the maximum communications gap that would occur with the reduced network configuration in the event the communications link was lost with the TDRSS. The results are as follows:

SPACECRAFT	REQUIRED CONTACT TIME	MAXIMUM GAP TIME
COBE	4 HOURS	4 HOURS
UARS	33 DAYS	10 HOURS
GRO	7 DAYS+	9 HOURS
HST	3 DAYS+	15 HOURS

The spacecraft have been designed to automatically transfer to a "safe mode" upon the loss of TDRSS service. Simultaneous failures of both the TDRSS Space Network and the spacecraft safe mode were considered "sufficiently improbable not to warrant the expense of maintaining ground stations to protect against it."

QUESTION 5:

An example of a satellite that suffered a serious malfunction but was saved by the ground station system was ERBS; could it have been saved if the four stations had been removed from the system?

ANSWER 5:

The ERBS emergency was caused by an incorrect command sent as a test to the spacecraft. The "safe mode" had been disabled for the test. The command fired thrusters incorrectly and the spacecraft began tumbling. All stations in the ground network tracked the spacecraft and a "safe" command was successfully initiated. If the four stations had been closed during this event, the time to "safe" the spacecraft could have been extended due to the increased gaps in coverage. However, the spacecraft would have still been recovered.

QUESTION 6:

What specific plans is NASA making to provide ground-based communications to future degraded missions, beyond emergency health and safety support?

ANSWER 6:

NASA policy since the inception of the TDRSS Space Network has been to provide science communications via the TDRSS. Spacecraft are designed to function in this mode. In this environment, the ground network is only capable of providing emergency health and safety support to save the spacecraft, but does not provide for retrieving science data.

QUESTION 7:

What analysis has been done of the compatibility of foreign or commercial facilities for use in such a contingency? How quickly could they be made available and at what cost? How reliable would support from foreign providers be?

ANSWER 7:

The present and future generations of spacecraft are designed to operate with a space-based network and are basically incompatible with terrestrial networks of any nationality.

QUESTION 8:

What type of records does NASA maintain on spacecraft emergencies and the ground stations that are used to resolve them? If these records exist, what do they say about the importance to spacecraft health and safety of the four stations planned to be closed?

ANSWER 8:

In the TDRSS time frame, there have been only a few instances where the ground network provided rescue services for malfunctioning spacecraft. One of these was the ERBS failure discussed previously. Records have not been retained regarding which station(s) in the network were instrumental in the recovery. Reduction of the network simply increases the possibility that recovery times will be extended if the failure occurs under worse-case conditions as to time and orbit.

QUESTION 9:

If you modify the 7th TDRSS for Ka, does it eliminate the need for Advanced TDRSS?

ANSWER 9:

No. The Advanced TDRSS is a competitive spacecraft procurement which will provide additional spacecraft to replenish and maintain the TDRSS Space Network when the current generation of spacecraft are depleted. The Advanced TDRSS Program is planned to provide service until 2010. Ka band is one of the Advanced TDRSS enhancements expected to provide increased bandwidth and data capability for NASA missions in this time frame.

QUESTION 10:

Please submit for the record a complete chronology of events regarding the American Rocket Company's contact with NASA on the RFP issued for the development of a hybrid. Please include a description of NASA's response to these contacts.

ANSWER 10:

As a consequence of the Challenger accident, NASA initiated an effort to investigate the replacement of the solid rocket boosters on shuttle with an engine that could be shut down if necessary. Both hybrids and liquids are candidates. Over the past two years, NASA's Civil Space Technology Initiative (CSTI) Booster program has been formulating a technology effort so that hybrid (solid fuel/liquid oxidizer) propulsion can be considered as a candidate for possible replacement of the solids on the Shuttle. Hybrid Boosters have several advantages over solids: abort mode on/off control; thrust modulation; high performance; clear booster exhaust and low development and production costs. Over the past 20 years, approximately 20 U.S. industrial firms and 8 universities have been involved with hybrid propulsion. Eight foreign countries have published literature on hybrid motors. A target drone powered by a hybrid engine was flown in 1984.

The primary focus of the OAST program is on highly reliable systems, with high thrust (750,000 to 3,000,000 lbs), high performance and low life cycle cost. The OAST technical strategy is to provide basic understanding and confidence regarding the application of hybrid technology to future full-scale systems through a combination of subscale component testing, accompanying analysis and design, and analysis verification in larger subscale motor tests. In contrast, the AMROC development philosophy is to provide low cost transportation of payloads to and from low Earth orbit; to provide suborbital commercial service by late 1989, orbital by 1990; and to provide several hundred launches within 10 years. The AMROC approach is to develop a low-cost launch vehicle through heavily empirical and limited analysis, utilizing a minimum data base.

Chronology:

- The NASA Marshall Space Flight Center (MSFC) issued an RFP on June 10, 1988, for a hybrid design study and for the definition of a technology effort that would be required to bring the hybrid concept to a point that would allow it to be considered for use as a replacement engine for the Shuttle solids.
- As a result of an AMROC letter dated June 29, 1988, to DOT, the RFP response date was suspended on July 7, 1988, to allow an investigation of AMROC's concerns that the technology NASA was seeking was available from AMROC and awarding a contract to other firms would subsidize AMROC competitors.
- On July 26-27, 1988, a MSFC Ad Hoc team visited AMROC and concluded that AMROC did not possess the technical capability to fully satisfy the RFP.
- AMROC was notified on August 16, 1988, that their work did not meet NASA's requirements for performance, reliability, scalability and technology understanding.
- On August 18, 1988, the RFP was rewritten for clarification. On August 22, 1988, AMROC sent a letter to Mr. Jack Lee, Deputy Director of the MSFC, disagreeing with the August 16, 1988,

findings. On August 23, 1988, AMROC submitted a formal protest to the GAO.

- On September 29, 1988, NASA's response to the AMROC protest was filed. The NASA position was that AMROC's technology did not meet NASA's technical needs based on several technical arguments: (1) reliability; (2) scalability; (3) performance and (4) the AMROC approach is limited to one concept. NASA's actions are designed to foster and encourage competitive commercial involvement in the hybrid area without significantly duplicating existing work.

- On January 4, 1989, the GAO disallowed AMROC's protest (File # B-232391) and on January 5, 1989, NASA was notified that the GAO had disallowed the protest.

- March 3, 1989, MSFC Center Director, J. R. Thompson, received a letter from AMROC proposing a fixed price build of a two-segment hybrid. Only performance data would be made available. On March 22, 1989, MSFC Director of Procurement, C. Henke, responded that, in order for NASA to consider AMROC's letter, a formal proposal would be required. MSFC provided AMROC the necessary information to prepare a formal proposal.

- In March/April 1989, four contracts were awarded for the study effort. AMROC did not choose to submit a proposal, although full assurances regarding the protection of proprietary rights was given to all proposers. Following the study efforts (approximately six months), one or more contracted efforts are planned to conduct the requisite technology efforts.

QUESTION 11:

Please describe the personnel situation at Goddard including plans for increasing the staffing in the future and the amount of personnel allowed to be hired at Goddard versus the amount of money available to pay the personnel out of the R&PM budget. Also, discuss the limitations of attracting and retaining personnel at Goddard.

ANSWER 11:

In response to your request for information regarding concerns about the Goddard Space Flight Center workforce, let me begin by discussing overall the NASA civil service workforce. During the summer of 1988, NASA completed an in-depth review of its workforce requirements. The results of the study indicated that based to a large degree on Shuttle, Space Station Freedom, science program needs, and to a lesser extent on core research and technology capability requirements, NASA would need an increase to its current workforce. After discussion with OMB relative to the results of the workforce review, OMB agreed that NASA's Full-Time Equivalent (FTE) authorized ceilings be increased in FY 1989 and 1990. Current budget levels in Research and Program Management will not allow us to fully fund this FTE augmentation but we have remained committed to achieving these levels in both FY 1989 and 1990. Every possible effort will be made to secure funding so that planned programmatic activities can be realized. We realize that the manpower shortfall affects all the NASA installations, and we are working to correct those shortfalls.

In the specific case of the GSFC, the workforce shortfall is the result of several factors. Among the largest contributors is the delay in launch of several spacecraft which resulted from the Challenger accident. These spacecraft include the Tracking and Data Relay Satellites (TDRS), the Gamma Ray Observatory (GRO), the Upper Atmosphere Research Satellite (UARS), and the Cosmic Background Explorer (COBE). The launch delays, and in some cases, significant rework as a result of launch manpower which has been planned to be reassigned to new programs. Other key contributors to the manpower shortfall are the Space Station Freedom work package effort at GSFC, the effort associated with Freedom science payloads such as the Earth Observing System.

APPENDIX 4

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of XC:MDD:01115f

JUN 21 1989

Ms. Susan Dumay
Hearing Coordinator
Subcommittee on Space Science
and Applications
Committee on Science, Space
and Technology
House of Representatives
Washington, DC 20515

Dear Ms. Dumay:

Enclosed are the final responses to written questions submitted by Chrm. Nelson resulting from the March 9, 1989, hearing at which Dr. Martin testified on the FY 1990 space exploration budget request.

This material completes the information requested during that hearing.

Sincerely,

Mary D. Kerwin

Mary D. Kerwin
Director, Congressional Liaison Division

Enclosures

Responses to Written Questions Submitted by Chrm. Nelson.

QUESTION 1:

What are the mechanisms by which the Office of Exploration can influence near-term programs such as Space Station and studies on heavy-lift vehicles (i.e. Shuttle-C)?

ANSWER 1:

The NASA Headquarters program offices participate in Office of Exploration studies and are represented on the Exploration Management Group. Through this process the program offices assess the implications of potential human exploration missions on their ongoing programs and future planning activities. Eight program offices support this activity by working in specific functional areas as described below:

* The Office of Space Flight
  Earth to Orbit Transportation Analysis:
    - Integrated traffic/capacity analysis
    - Fleet strategy analysis
    - Transportation/accommodation analysis
    - Personnel transport accommodations
    - Integrated servicing analysis

* The Office of Space Station
  Space Station Freedom Evolution Analysis:
    - Case study prerequisite accommodations
    - Evolution capabilities of Station
    - Personnel logistics accommodations capability
    - Accommodations cost analysis

* The Office of Space Science and Applications
  Mars and Lunar Science Precursor Missions:
    - Mars and lunar precursor mission concepts
    - Precursor mission cost analysis
    - Precursor/human mission science strategy

  Life Sciences Program Analysis:
    - Long-duration human space flight research
    - Planetary protection and quarantine analysis
    - Prerequisite program cost analysis
    - Human space flight prerequisite technology demonstrations

* The Office of Aeronautics and Space Technology
  Technology Program Analysis:
    - Pathfinder technology analysis
    - Technology program cost analysis
    - Technology verification requirements

* The Office of Space Operations
  Operations Capability Extensions and Analysis:
    - Integrated communications and tracking requirements
    - Facilities requirements
    - Capability development cost analysis

- The Office of Management
  Personnel and Institutional Analysis:
    - Personnel requirements analysis
    - Critical skills development
    - Innovative mission management/organizational concepts

- The Office of Commercial Programs
  Commercial Analysis:
    - Terrestrial analog study
    - Enterprise Case study

QUESTION 2:

Are there any changes in legislation or organization that would benefit the Office of Exploration?

ANSWER 2:

The Office of Exploration activities are currently being funded through existing program office budgets. From an organizational point of view, at some point in the future is may be appropriate to seek study support through a separate budget line item. This would convey a message that the effort being undertaken is not just another ad hoc exercise and that there is a permanence of purpose for human exploration planning.

From a legislative point of view, the approval of NASA's FY 1990 budget request would be extremely beneficial to our Office. This budget includes funding for the essential prerequisites for eventual human exploration missions, particularly in the programs of the Space Station, life science research, Pathfinder technology research, unmanned precursor missions, and Earth-to-Orbit transportation needs. Delaying a commitment to these near-term requirements will cause an increase in resource requirements for the parallel continuation of options, which get larger with time; a delay could also necessitate a corresponding yield on the timeline for exploration accomplishments.

QUESTION 3:

Given the capability of the USSR, especially in heavy-lift launch vehicles, would it be desirable to try to forge cooperative agreements with them on manned missions at the same time we are negotiating with our allies?

ANSWER 3:

Clearly, missions of human exploration to the Moon or Mars are strong candidates for cooperative missions with the Soviet Union and could take place in the early part of the next century. At that time, it is expected that both the U.S. and U.S.S.R. would have heavy-lift launch capabilities and could both contribute to launch requirements for such missions.

In the meantime, it is premature to commit to any particular mission or exploration scenario at this early phase of our human exploration studies or to make decisions with respect to possible international cooperation. However, the normal process of international communication, while informal, can provide us with an important link to what other countries are planning.

With regard to the Soviet Union, we have several cooperative activities in the area of solar system exploration. The planned Soviet Mars 1994 mission will be coordinated with the U.S. Mars Observer mission, and we will exchange scientists on these and the Magellan mission to Venus. The U.S. is planning to fly a French-built transponder on Mars Observer to relay data from a balloon experiment on the Soviet Mars 94 mission. Finally, in accordance with a May agreement to exchange the results of independent national studies, both sides will summarize studies on Mars Rover Sample Return missions and Lunar Orbiter/Science Outposts.

The steps we are taking now in our joint activities with the USSR will put us in a position to move to more ambitious cooperation in unmanned or even future human exploration missions if such cooperation appears to be justified, based on experience in the early stage and the prospects for a future U.S.-Soviet stable political relationship. Once the direction of the U.S. program is decided, all possibilities for international collaboration will be explored.

QUESTION 4:

What is the current schedule with intermediate milestones for achieving a consensus and deciding on the next major manned goal for the U.S. space program?

ANSWER 4:

For the purpose of our studies, we have assumed that a consensus and decision could be achieved in the early 1990s timeframe.

In laying out a study plan of potential human exploration missions, a high priority has been placed on positioning this Nation to accomplish exploration objectives in the first decade of the 21st Century, while, at the same time, not allowing that desire to drive required investments in the nearer term beyond levels that are considered reasonable or practical. The current phase of our planning is geared toward examining multiple options and initiating a technology foundation.

This phase of the program began with the release of the Directive on National Space Policy, commitment to start the Pathfinder technology program, and the formation of the Office of Exploration. Our current studies serve to refine and steer long lead-time technology developments undertaken in near-term NASA programs. Many of the investments required to keep a wide range of options open are common across defined cases.

At the completion of this phase, a comprehensive understanding of the options in terms of technical and policy benefits, as well as an estimate of costs and program schedules, will be available. The information will support a decision on a strategy of going to either the Moon or Mars first and a definition of specific objectives. Having accomplished the necessary planning and studies, an approach to international cooperation on precursor science missions and prerequisite life sciences research is also decided as part of this milestone in preparation for the actual hardware start of those programs.

For the purposes of our studies, we have assumed that this phase could be completed in the early 1990s timeframe.

QUESTION 5:

1992 is the International Space Year. What is the Office of Exploration doing to initiate a cooperative program in manned exploration at that time.

ANSWER 5:

NASA was instrumental in the establishment of the Space Agency Forum on International Space Year (SAFISY), specifically to foster worldwide coordination of ISY activities among space agencies. To date, only Mission to Planet Earth has been endorsed by SAFISY as an ISY theme. NASA is reviewing human exploration as another theme which could be proposed to SAFISY in the future.

Although NASA believes it is premature to commit to any international cooperation at this early phase of our exploration studies, we have begun a dialogue with friends and allies to explore their interest in potential cooperation in human exploration in the future, whether or not it is to be carried out under the auspices of ISY.

APPENDIX 5

PRELIMINARY ANALYSIS OF NASA COMMERCIALIZATION INITIATIVES

Staff Memorandum
February 1989

The Congress of the United States
Congressional Budget Office

PREFACE

David H. Moore of the Congressional Budget Office's Natural Resources and Commerce Division, and Michael Sieverts of the Budget Analysis Division, prepared this memorandum. It was undertaken in response to a request from the Commerce, Science, and Transportation Subcommittee on Science, Technology and Space. The memorandum provides a preliminary analysis of several commercialization proposals in the 1990 budget request of the National Aeronautic and Space Administration. Francis Pierce edited the memorandum. Margaret Cromartie prepared the many drafts.

February 17, 1989

CONGRESSIONAL BUDGET OFFICE
STAFF MEMORANDUM

PRELIMINARY ANALYSIS OF NASA COMMERCIALIZATION INITIATIVES

This memorandum analyzes several proposals to "commercialize" various parts of the National Aeronautics and Space Administration (NASA) program. The conclusions drawn in the memorandum are tentative, and will be revisited in a Congressional Budget Office (CBO) special study to be completed during the spring of 1989.

The seven specific commercialization proposals in NASA's 1990 budget request all seek to draw private capital into the development of the nation's space infrastructure, in exchange for long-term government commitments in the form of leases or service contracts. NASA is currently soliciting private-sector interest in its proposals, and no specific terms have been presented to the Congress. NASA has indicated that the federal government would enjoy savings, relative to direct procurement, if non-U.S. government customers shared with NASA the use and cost, including the higher capital costs, of the privately financed facilities. The recent history of space commercialization does not give cause for optimism that customers other than the U.S. government will share the cost and use of the facilities. Specifically, there is not likely to be any demand from sources outside the U.S. government for three of the seven proposed projects: the space station flight telerobotic system, the advanced solid rocket motor plant, and the observational instruments laboratory.

This weakness of the potential non-U.S. government demand for the facilities and hardware proposed for commercialization could leave NASA without private offers that accept the risk of even a low level of shared use and cost. In this circumstance, the cost of private financing would be greater than the cost of direct procurement. If the commercialization initiatives were permitted to go forward, even though they were likely to be more expensive than direct procurement, it would be reasonable for the Congress to expect some additional benefit to the nation in return for the additional cost incurred through private financing. NASA has alluded to additional benefits, without being specific as to what they might be.

NASA has acknowledged that its proposals will shift budgetary outlays from fiscal years 1990 and 1991 into the future--as much as $110 million in 1990 alone. NASA represents this shift as desirable because it views its current and proposed budgets as barely adequate to cover the cost of the space program. NASA received a 21 percent increase in its appropriation for 1989, and the 1990 budget request includes another 22 percent increase, largely to cover the cost of the space shuttle and space station programs. The 1990 budget request indicates that large future increases will also be required by NASA, and that NASA and the Office of

Management and Budget (OMB) will continue to explore commercialization options deferring outlays into the future. Whether or not proposals of this type would ultimately cost the government more than direct procurement, the practice of shifting outlays into the future, if extensively adopted, would saddle NASA with a substantial mortgage payment.

The budgetary treatment of NASA lease or service contract payments is uncertain, because NASA has yet to submit draft legislation to the Congress. In general, the government is required by the Anti-Deficiency Act (31 USC 1341) to provide funding to cover its current liabilities. Unless an exception was made, the appropriations necessary for these initiatives might be roughly comparable to those needed for direct procurement, in which case NASA would not decrease its near-term budget authority requirement.

If the private sector responds to the commercialization initiatives with offers that allow the government to reduce its costs, this will be consistent with the Administration's broader policy of promoting commercial space activity through the cost-effective purchase of goods and services from the private sector. Yet, even in this circumstance, NASA's proposals might require an exception to normal scorekeeping procedures, setting an undesirable precedent for other agencies and departments. Moreover, the current proposals, and others to come, might encumber both NASA and future Congresses with mandatory payments for programs and projects that are at the mercy of inherently unpredictable events.

I. BACKGROUND

President Reagan's 1990 budget request for the National Aeronautics and Space Administration includes "space commercialization" as a major policy initiative.[1] President Bush explicitly endorsed this initiative in Building a Better America.[2] The Administration thrust is consistent with initiatives released during 1988 that called for increased private-sector participation in the national civilian space program.[3] The NASA budget request includes support for industry and university collaboration in exploring "the potential uses of space for future economic gain" and for procurement of launch services from the private sector for NASA missions, and announces NASA's intention to seek private-sector financing for portions of its space transportation and space station programs.[4]

The intention to seek private financing for NASA facilities and hardware programs represents a new direction for the NASA program. It would defer some budgetary outlays to the future by means of service contracts and leases to private investors. A complete analysis of these space commercialization initiatives must await more specific information concerning the proposed agreements between the government and private investors, since a variety of options would be open to both parties. Nevertheless, the initiatives included in the 1990 budget raise a number of general issues. This memorandum addresses some of these issues in examining the larger policy behind the proposals, estimating their cost to the government, and briefly examining some budgetary and scoring concerns.

II. THE POLICY OF SPACE COMMERCIALIZATION

In February 1988, NASA released the broad outlines of a long-awaited National Space Policy, a set of commercial initiatives including both general policy statements and specific program proposals. These statements comprise the policy underlying the 1990 budget initiatives, and are explicitly referred to by NASA in its presentation of the Administration's 1990 budget request.[5]

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[1] Budget of the United States, Fiscal Year 1990: Major Policy Initiatives, p. 46.

[2] Building a Better America (The White House), February 9, 1989, p.35.

[3] Congressional Research Service, Civilian Space Policy Under the Reagan Administration: Potential Impact of the January 1988 Directive, Report No. 88-237(March 1988),pp 15-18.

[4] Budget of the United States, Fiscal Year 1990: Major Policy Initiatives, p. 45.

[5] National Aeronautics and Space Administration, Budget Estimates, Fiscal Year 1990 (January 1989).

The National Space Policy is fully articulated in a classified National Security Decision Directive prepared by the National Security Council in January 1988. An unclassified summary, released in February 1988, placed new emphasis on a private-sector role in the national civilian space program, asserting that a "non-governmental Commercial Space Sector," driven by market forces, would generate economic benefits for the nation and support the public-sector space effort by "increasing the range of space goods and services."[6] The major policy initiatives intended to promote the commercial space sector were prepared by an interagency group consisting of NASA and the Departments of Defense, Commerce and Transportation, designated as the Commercial Space Working Group of the Economic Policy Council.[7]

The space policy directive provides for government actions to encourage a market-driven commercial space sector, and prohibits other government actions that could discourage private-sector involvement in space. It calls for government procurement of "commercially available" space goods and services "to the fullest extent feasible" as the principal new means of stimulating private-sector investment, ownership, and operation. Commercial availability is defined to include services currently on the market--for example, launch services--and other services that "could be supplied commercially in response to a government service procurement request." Feasibility requires that the services procured meet a mission requirement "in a cost effective way." The government would be prohibited from competing with the private sector in markets where commercial space services are provided. The Space Station, NASA's major development project for the 1990s, is singled out as a program where the possibility of space commercial activity is to be explored by both NASA and OMB: "NASA will seek to rely to the extent feasible on private sector design, financing, construction, and operation of future Space Station requirements...."[8]

III. COMMERCIALIZATION PROPOSALS IN THE 1990 BUDGET

NASA is pursuing private financing for seven specific projects. Four are construction projects, and the other three are development projects with specific hardware objectives. The budget also proposes exploration of private financing options for additional space station systems and equipment, including a solar dynamic power system. A supporting document, Major Policy Initiatives, also indicates that a leasing arrangement will be pursued for the Commercially Developed Space Facility, a small privately owned and operated space station to be launched and periodically visited by the space shuttle and its crew. NASA's projected budget request includes $185 million through 1992 for this project, which was proposed in 1984 and adopted by the February 1988 commercial space initiatives.

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[6] "Fact Sheet: National Space Policy" (The White House), February 11,1988.

[7] Congressional Research Service, Civilian Space Policy under the Reagan Administration, p. 16.

[8] "Fact Sheet: National Space Policy."

The seven projects for which private financial participation is sought are:

- The Advanced Solid Rocket Motor production and test facility, that will produce solid rocket motors to support the space shuttle program, and is to be built in Yellow Creek, Mississippi.
- The Space Station Processing Facility, to be built at the Kennedy Space Center, that will first prepare for launch and inspect the elements of the space station, and later perform a similar function for upward-bound and returning cargo.
- The Neutral Buoyancy Laboratory, to be built at the Johnson Space Center, an indoor swimming pool-like structure and support facility that will be used to simulate the Extra Vehicular Activity or "space walking" required in building, operating, and maintaining the space station.
- The Observational Instruments Laboratory, to be built at the Jet Propulsion Laboratory in Pasadena, California, which will be used to develop and assemble observation instruments for a wide array of missions from earth observation to planetary exploration to astronomy.
- The Space Station Flight Telerobotic Servicer, a mobile robotic arm attached to the space station structure that can be used by astronauts within the space station to perform station maintenance and other tasks requiring activity outside the station.
- The Extended Duration Orbiter, a pallet that will hold cooling supplies and hardware, to be carried in the shuttle cargo bay. It will allow the current 10-day limit on shuttle flights to be extended to 14 to 16 days or more.
- A Space Station Docking System to permit the shuttle or other vehicles to join with the space station or other proposed space platforms such as the commercially developed space facility.

Table I lists these projects and the budget authority NASA would have requested in 1990 had it planned to finance them in the traditional way. Estimates are also shown for the total budget authority NASA would require for each project through 1994 were it to proceed in the conventional way. Were the seven projects

TABLE 1. COMMERCIAL INITIATIVES IN THE 1990 BUDGET: AVOIDED BUDGET AUTHORITY REQUESTS (In millions of dollars)

Proposal	1990	1990-1994
Construction of Facilities		
Advanced Solid Rocket Motor Production and Test Facility	60	300
Space Station Processing Facility	43	84
Neutral Buoyancy Laborator	30	30
Observational Instruments Laboratory	14	14
Subtotal	147	428
Development Projects		
Space Station Telerobotic Servicer	30	173
Extended Duration Orbiter Kit	27	97
Space Station Docking System	4	76
Subtotal	61	346
Total Initiatives	208	772

SOURCE: National Aeronautics and Space Administration.

financed through private capital markets instead, all or part of the 0.8 billion dollars that would have been required to cover the cost of conventional procurement during the next 5 years would be spread out over the next 15 to 20 years.

NASA has yet to propose the exact terms upon which this type of commercialization would be undertaken, and is in the process of soliciting private-sector interest. Two general types of agreements have been discussed; private financing of facilities and hardware with a leaseback to the government, and service contracts under which the private investor would offer to finance the facility's construction (or hardware production) and, subsequently, operate the facility. In the seven initiatives proposed, the most reasonable assumption is that production, construction, and financing could be separated from operation. Thus, the question of the terms and conditions necessary to enable private financing of production and construction to be cost-effective to the government can be addressed independently of the question whether it would be cost-effective for the government to contract out the operation of a facility or system once it had been built or produced.

Preliminary discussions have been held by both NASA and OMB with parties interested in financing at least one of the hardware projects. The Goddard Space Flight Center is considering amending its Request for Proposal on the space station flight telerobotic system to include private financing options. Requests for information have been released seeking private interest in the Space Station Processing Facility and the Neutral Buoyancy Laboratory. The bidders in the Advanced Solid Rocket Motor competition, which is currently before a source selection board, were requested to provide private construction financing options in their offers tendered in 1988. It is unclear, however, whether the absence of funds in the 1990 budget for government financing of this construction will affect these ongoing deliberations and how, if government financing is chosen, the option will be funded. The Observational Instruments Laboratory is a special case, in which the only offer is expected to come from the California Institute of Technology, a not-for-profit institution that is the home of the Jet Propulsion Laboratory, a federal contract research center devoted to NASA programs.

IV. PRIVATE CONDITIONS AND PUBLIC COSTS

Until NASA finishes gathering information about the terms and conditions necessary to secure private financing, no data will be available for analysis. It can be stated, however, that if the lease or service contract arrangement is to be less expensive to the government than direct procurement, the government will have to share the use and cost of the facilities or hardware with other customers. An example would be a space station facility that the government uses fully during the deployment--thus, a smaller, lower-capacity alternative would not do--but thereafter shares with another user. For the government to realize cost saving from private financing, the lower "principal" payments permitted by sharing with a non-U.S. government user must be sufficient to offset the higher interest cost of borrowing at the private, as opposed to the government, rate.

The Cost of Private Participation

NASA has performed a preliminary analysis of three of the construction projects proposed for commercialization, comparing the cost of traditional procurement and government ownership with private financing and leaseback to the government. The general results of these analyses hold for the four other projects not included.

The analysis shows that the direct cost to the government would depend on the extent of non-U.S. government demand for the facility or hardware.[9] As illustrated in Table II, commercialization would either cost or save the government money relative to a direct purchase, depending on the assumptions made about non-U.S. government demand. If the government were to lease the entire use of all three facilities, then it would eventually pay a higher price, by over $15 million, than if it purchased the facilities outright, because private financing of the whole facility would be more expensive than government financing. If the government were to lease only 80 percent of the three facilities, however, it could save over $8 million. In this simplest of cases, in order for the government to enjoy a cost saving from leasing, the reduced cost from leasing only part of a facility must be sufficient to offset the cost of higher private-sector financing rates -- assumed to be 2.7 percentage points higher in the NASA analysis. According to OMB Circular A-104, a leasing arrangement must pass this type of cost test in order to be preferred to an outright purchase. NASA has indicated, however, that OMB might grant an exception to circular A-104, under the provision of a memorandum that permits exceptions "to lease purchase special purpose facilities, which may be considered on a case-by-case basis, as part of the annual budget review process."[10] Under such an exception NASA would be permitted to go forward with the commercialization options, whether or not they cost the government more than traditional procurement.

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[9] The method NASA used to estimate the cost of a direct government purchase as compared with a lease purchase agreement is described in OMB circular A-104. This method compares the present value of a direct government purchase with the present value of the stream of lease payments to be made by the government, plus tax benefits granted the lessor and additional costs incurred as a consequence of private ownership, in this case insurance.

[10] Memorandum for Heads of Executive Departments and Agencies from Joseph R. Wright, Acting Director, Office of Management and Budget, October 19, 1988.

TABLE 2. DIRECT PROCUREMENT VERSUS LEASING: COST (SAVING) TO THE GOVERNMENT UNDER ALTERNATIVE LEVELS OF GOVERNMENT USE
(In millions of dollars)

Project	100 Percent U.S. Government Lease[a]	80 Percent U.S. Government Lease[a]
Space Station Process Facility	11.0	(4.5)
Observational Instruments Laboratory	2.2	(1.3)
Neutral Buoyancy Tank	3.5	(2.4)

SOURCE: National Aeronautics and Space Administration.

NOTE: The analysis is based on the following assumptions: amortization period, 15 years; discount rate, 9.3 percent; inflation rate, 4.5 percent; construction loan rate, 12.5 percent; long-term amortization rate, 10.5 percent.

a. All numbers are additions to or subtractions from a baseline predicated on direct procurement.

The Non-U.S. Government Market for Space Infrastructure Facilities and Services

Even though NASA could be relieved of the burden of demonstrating that its commercialization initiatives are less costly than direct procurement, the question of commercial demand for the facilities and hardware remains important. Ultimately, a broader market must develop if the National Space Policy objective of a market-driven commercial space sector is to become a reality. Requests for information are a first test of whether a potential commercial demand for space infrastructure exists. If the material submitted to NASA indicates that bidders are willing to bear the risk of commercial failure, and to accept a government lease covering less than the full value of the facility, this will indicate that the policy of commercialization may be a cost-effective step toward a market-driven commercial space sector. If NASA cannot find a bidder willing to bear the risk of the private market, this will suggest that the market's assessment of private demand is negative.

NASA has not estimated the likely sources of commercial demand for the facilities and hardware. However, they include foreign governments, private corporations, and non-profit institutions such as universities and research institutes. Among the four facilities projects neither the solid rocket motor plant nor the observational instruments laboratory is likely to be of interest outside the federal government. The same is true of the telerobotic servicer.

The four other initiatives have more potential. The neutral buoyancy laboratory may attract firms interested in developing undersea technology for petroleum extraction. Shared use of this facility would have to be carefully managed, however. NASA has indicated that even after the launch of the space station, a full-scale model of the habitation and laboratory modules would be kept in the tank to simulate repair operations in case of an emergency during orbit. Private use of this facility would have to be consistent with that safety constraint.

The space station processing facility has a potential commercial market in the processing of cargo. Initially, this market is likely to consist of small experiments that explore the possibility of manufacturing pharmaceutical, semiconductor, or other materials in space. While private firms would bear some of the cost of these experiments, they would probably need full or partial subsidies from the U.S. or foreign governments until profitable space processing ventures are established. To the extent that the cost of subsidizing new space commercial prospects in areas like materials processing would be increased by the need to pay private owners market rates for infrastructure facilities and services, the apparent saving to the U.S. government attributable to shared use leasing would be offset by these higher charges. It is not clear whether NASA has taken account of such higher costs in its proposals to commercialize various rungs of the vertical ladder necessary to develop new space products and services. The higher costs would be incurred both under subsidy and in the early years of unsubsidized commercial activity, should such activity prove viable.

The extended duration orbiter kit could also serve the space experiments market, and be rented to foreign governments or private firms as well as the U.S. government. Extending the duration of a shuttle flight enables more or longer experiments to be performed, increasing the value of the flight. In this case, however, as in that of the space station processing facility, interjecting a private profit-making venture into the set of steps necessary to perform an experiment in space could increase the cost to the government of subsidizing new products and processes.

Finally, the docking module hardware may find a private market if privately owned and operated space platforms come to be. Before that, however, substantial public expenditure on the space platform would be needed.

The most pertinent near-term test of commercialization will come in the terms and conditions private proposals will require. Those that accept the risks of the commercial market will provide the government with more cost-effective facilities and hardware than it can obtain through direct procurement.

Current Proposals and Recent History

NASA has in the past sought to encourage private investment in space infrastructure. CBO is currently reviewing these efforts as a part of a larger study of space commercialization. The record is a mixed one, from the perspectives of both the government and the private investor.

The Tracking and Data Relay Satellite System was initiated as a private investment that relied on the government as its primary customer. The early discussion of the program resembled the current discussion of some of NASA's privatization initiatives. Private bank financing was sought, but when this was not forthcoming, NASA borrowed the funds from the Federal Financing Bank and passed them on to the private investors--a joint venture consisting of communication and aerospace firms. NASA was to be the dominant customer, sharing the use and cost of the satellite system with the private sector. The government would meet its own needs in a cost-effective way and at the same time stimulate private investment in advanced communications satellite applications. The technology was portrayed as not too risky for private investors, as the contractor was moving forward on a design of its own with some commonalities. As an effort to expand private investment in space infrastructure, this venture failed--the system was financed by the government and is currently owned by the government--and the case for its privatization fell apart. The venture proved risky technically in and of itself, and also because it depended on the complementary, but extremely risky, shuttle program for its full realization. The government became and remains the sole user. NASA was forced to assume full responsibility for the loans, and still makes annual payments from appropriated funds to the Federal Financing Bank.

A somewhat more positive case from the government's point of view, is the McDonnell Douglas investment in the upper-stage rocket, the payload assistance module, and its variants (PAM), but this venture probably has not lived up to the expectations of the investor. The product was developed for both the government market and the private satellite market. McDonnell Douglas committed its own funds in anticipation of government business, but also was willing to accept the risk of the commercial market. Sales were initially lower than expected because development of the shuttle took longer than expected, and the flight rate failed to meet advanced projections. Moreover, the demand for communications satellites proved to be substantially less than the industry's consensus forecast. The ban on communications satellite bookings that followed the Challenger accident further diminished the market. Currently, McDonnell Douglas indicates it has not recovered its investment of $150 million in the PAM upper-stage family, 14 years after it initiated the venture. From the government's point of view, however, the PAM case showed that private investment, driven by the expectation of a commercial market, can create a wider choice of space goods than under the traditional NASA approach and at a lower cost to the government.

These cases and others suggest that commercial space activities are still some distance from becoming the major sector of economic activity that space enthusiasts foresee. An implication of this recent history for the 1990 budget initiatives proposed by NASA is that private markets may not come forward with terms and conditions that meet the kind of test suggested by A-104. Should the government choose to go forward regardless, the cost of the lease-purchase options could be viewed as an investment in encouraging private investment in commercial space. The higher cost of using privately owned facilities and hardware could conceivably, further this end in demonstrating the viability of a commercial infrastructure venture. Perhaps, also, the existence of private owners and operators experienced in doing business with the government could smooth the way for other space investors who are unfamiliar with the process.

For the government, the history of commercial space investment suggests that the choice of projects for commercialization must be carefully made. The selection of projects must take into account that private facilities and hardware will invariably be dependent on the highly technical, and often risky, parts of the space infrastructure operated by the government. The private sector's return on its investment will inevitably depend upon having assured access to the public infrastructure. This access is not only constrained by government policy, but also by events unaffected by policy such as technical delays or catastrophes like the Challenger accident. If the recent history of NASA infrastructure efforts is any guide, the schedule for its new initiatives is likely to experience delays similar to those of the past.

V. BUDGET ISSUES

NASA's proposals raise at least two substantial budget issues. The first has to do with the merits of shifting NASA outlays into the future. The second is how the leasing commitments NASA proposes to make should be treated in the budget.

Deferring Outlays into the Future

By commercializing construction and hardware projects, NASA would be able to stretch over the next 15 to 20 years outlays that would be made in the next five years if it acquired the assets in the traditional way. This deferral of outlays is held to be an advantage of the proposal. In general, current budget practice does not see this type of stretch-out as an advantage, particularly if it increases the cost to the government. OMB states in its analysis supporting President Reagan's 1990 budget, "Such arrangements understate the true cost of capital acquisition in the budget and allow the appearance of lower near-term outlays and budget authority at the expense of higher long-term costs."[11]

While the budgetary implications of the current proposals are relatively small, they might establish a precedent for similar proposals in years to come. Locking in future outlays in the form of lease or service contract payments would limit the Congress's options. If at some time the Congress felt it necessary to restrict NASA's budget, the existence of such long-term commitments could conceivably result in cutting high-priority programs rather than low-priority programs. NASA experience with the Tracking and Data Relay Satellite (TDRS) program highlights the difficulties of carrying these required annual payments. The annual payment to the Federal Financing Bank for the TDRS loan is $227.2 million, which is provided through appropriations and due on October 1 each year. In 1987, NASA missed the payment altogether and made the payment in installments instead in 1988. This restructuring of the repayments has increased the total interest due on the loan by over $100 million.

The shifting of outlays into the 1990s could compound the projected growth in NASA's overall costs. CBO analyzed these costs in a 1988 report, and found that NASA's budget authority requirement could grow to $18.4 billion by 1994 (in 1994 dollars), without any new initiatives such as a dramatic increase in Earth monitoring, a return to the moon, or a manned mission to Mars.[12] The President's budget, which does not include new project starts in the period 1991 through 1994 (the CBO analysis did) shows NASA's nominal dollar budget growing from $13.3 billion in 1990 to $16.7 billion in 1994.[13] When these growing program costs are considered against the background of the current effort to reduce the federal deficit, the argument for shifting expenses to the future loses much of its force.

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[11] "Federal Credit Programs," Special Analyses, Budget of the United States Government, Fiscal Year 1990, p. F-53.

[12] Congressional Budget Office, The NASA Program in the 1990s and Beyond, (May 1988), p. xv.

Scoring Leases

The budgetary treatment (scoring) of initiatives such as those being considered by NASA depends on the language authorizing them. As noted, NASA and OMB have not officially presented the exact terms for the seven proposals and this makes it impossible to say with any certainty how the proposals would be scored.

In general, the treatment of leases is governed by the Anti-Deficiency Act (31 U.S.C. 1341), which requires the lessee agency to obligate sufficient funds to cover the federal government's maximum current liability, as provided through appropriations acts. If sufficient funding is not provided through appropriations, then the lease can be scored as direct spending, as Congress may provide by law, with budget authority sufficient to cover future obligations recorded when the lease is signed, and the resulting outlays appearing when the lease payments are made. This scenario is similar to the treatment of subsidized housing contracts, which are multiyear rental assistance agreements: budget authority sufficient to cover the future stream of assistance payments is recorded when the contracts are signed.

Some leasing arrangements, on the other hand, do not commit the federal government to future obligations, and therefore do not require advance funding. Two lease-purchase arrangements authorized during the 100th Congress fall into this category. In these cases, both involving the construction of new office buildings, the authorizing legislation specified that the obligation of funds for lease payments may only be made on an annual basis, and would be subject to appropriations.[14] Other issues affect this determination however, such as the agency's liability associated with terminating the lease. These issues are usually specific to each lease and cannot be addressed until the authorizing language is presented, establishing the legal framework of the actual lease entered into.

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[13] Budget of the United States, Fiscal Year 1990, pp. 10-15.

[14] The two bills referred to here are S. 1550, the Federal Triangle project authorized by the Senate Committee on Environment and Public Works on July 29, 1987, and S. 1934, the Judiciary Office Building Development Act, as ordered reported by the same committee on April 22, 1988.

APPENDIX 6

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of: XC:MDD:00891f

AUG

Ms. Susan Dumay
Hearing Coordinator
Subcommittee on Space Science
  and Applications
Committee on Science, Space
  and Technology
House of Representatives
Washington, DC 20515

Dear Ms. Dumay:

Enclosed are the final responses to written questions resulting from the March 23, 1989, hearing at which Dr. Fletcher testified on the FY 1990 commercialization initiatives.

This material completes the information requested during this hearing.

Sincerely,

Mary D. Kerwin

Mary D. Kerwin
Director, Congressional Liaison Division

Enclosures

Responses to written questions submitted by Chairman Nelson

QUESTION 1:

For each Spacelab, pallet and MPESS mission that has already flown, what was the annual budget for:

a. Development, fabrication, testing and other charges associated with experiment hardware that will not be flown on subsequent missions;

b. Development, fabrication, testing and other charges associated with experiment hardware that can be flown on subsequent missions (such as the Shuttle Imaging Radar);

c. Onetime charges for integration of each type of experiment payload with Spacelab, pallet or MPESS;

d. Direct preflight and in-flight support activities, such as tracking and data relay;

e. Postflight experimental data reduction and analysis;

f. Other postflight costs, such as hardware de-mating, servicing, refurbishment and storage;

g. Other costs, such as crew training, mission planning, and management support, that can be allocated to specific missions;

h. Other annual cost, that cannot be allocated to specific missions.

QUESTION 2:

For each Spacelab, pallet and MPESS mission for which a flight date has been requested in the current Space Shuttle manifest, what is the actual and planned annual budget for:

a. Development, fabrication, testing and other charges associated with experiment hardware that will not be flown on subsequent missions;

b. Development, fabrication, testing and other charges associated with experiment hardware that can be flown on subsequent missions (such as the Shuttle Imaging Radar);

c. Onetime charges for integration of mission unique, reflight, and first-flight experiment payload with Spacelab, pallet or MPESS;

d. Direct preflight and in-flight support activities, such as tracking and data relay;

e. Postflight experimental data reduction and analysis;

f. Other postflight costs, such as hardware de-mating, servicing, refurbishment and storage;

g. Other costs, such as crew training, mission planning, and management support, that can be allocated to specific missions;

h. Other annual cost, that cannot be allocated to specific missions.

ANSWER 1&2:

Background: Based on the May 9, 1989, meeting with Bill Smith of the House Subcommittee on Space Science and Applications, and Joe Alexander and Bob Benson of NASA's Office of Space Science and Applications, the answers to the questions asked will reflect the reasons the questions were asked. The questions resulted from testimony given by Dr. Fletcher in which he stated that any slip in the position of a major mission on the manifest could be replaced with a Spacelab mission, so that no slots on the manifest would be lost. Chairman Nelson's staff wanted to determine the costs, etc., of various Spacelab missions to determine the accuracy of this statement.

If a slot on the manifest were to become available, there are three potential alternatives to maximize the Shuttle capacity using Spacelab missions: 1) moving a mission forward; 2) adding a follow-on mission (reflying previously flown mission); or, 3) adding a new Spacelab mission to the manifest.

1) Moving a Flight Forward. The first and most likely alternative to filling a vacated launch opportunity is to move a currently manifested mission forward. With approximately two years advance notice, a Spacelab mission can be moved forward on the manifest by as much as six to eight months to fill a gap, although moves of more than four months (with only two years notice) may be difficult because of the STS template and documentation requirements. When a mission is moved forward, near-term costs are likely to increase, sometimes dramatically, due to the compression in workload; however, many times the total runout costs are reduced somewhat since the total mission development time is decreased.

Whether a mission can be moved forward on the manifest depends on a number of factors. First, the technical readiness and complexity of a mission must be assessed. Technical readiness depends on where in the development and implementation schedule the mission is at the time of the manifest shift; the less mature the mission development, the less likely it can be moved forward, or the more expensive it would be to move. Similarly, the more complex the technology involved, the more time and effort must be put into its development, and the less likely that the work can be compressed into a shorter time period.

Second, the manifest must be assessed in terms of Spacelab hardware availability. For example, a Spacelab module generally requires nine to twelve months to refurbish from one mission to the next; a mission that requires a module generally cannot be added to a manifest slot that opens in between two other module missions. Missions that require a Mission Peculiar Experiment Support Structure (MPESS) or pallet are usually not so restricted.

Third, any consideration increasing work load by moving a mission forward must be assessed in terms of manpower availability. An example of a mission that was recently moved forward to cover a gap in the manifest is the International Microgravity Lab-1 (IML-1). IML-1 was moved up from February 1991 to December 1990 (two months). The move increased the FY 1989 and FY 1990 costs by an estimated $1.1 million, but reduced the overall mission cost by an estimated $.5 million.

Conversely, a mission can be slipped in the manifest, but by doing so the time the mission is on the ground increases, and subsequently the cost increases. The Spacelab Life Science-1 (SLS-1) mission recently slipped in the manifest two months, increasing its total runout by an estimated $1.0 million.

2) Adding a Follow-on Mission. With three to four years' advance notice, a vacated launch opportunity can be filled with the repeat of a previous flight, using the majority of the hardware previously flown. An example of such a mission would be an Astro-3 mission, flown as a near duplicate of Astro-2. A mission such as Astro-2 has such high scientific value that an identical reflight greatly enhances the amount of data gathered. The majority of the cost associated with this scenario would be attributable to integration costs since most of the hardware already would have been built and the documentation already written. In this example, the total cost of a reflight would be approximately $30 million. The feasibility of this alternative depends in large part on the scientific need for a reflight.

3) Adding a new Spacelab Mission. Given sufficient development time (3-5 years), an entirely new Spacelab mission could be designed to fill a vacated manifest slot, possibly using some combination of new and previously flown hardware. This is the most expensive alternative, and the least likely scenario since out-year manifest changes can be handled in a number of other ways without significant budgetary implications. New Spacelab mission costs can range from $50 million to $100 million, depending on the complexity of the technology and the availability of previously flown hardware.

Generalizations

Although there are specific implications associated with each of these alternatives relative to hardware development costs, the integration costs, data analysis costs, and other related costs, there are a number of generalizations that can be made.

Spacelab mission hardware: Generally, many Spacelab missions apply far more funding to hardware that is intended to be reflown (as opposed to mission specific hardware). Many of the currently planned missions use hardware that has flown on previous missions, and most of the instruments currently under development are planned to be flown repeatedly. Aside from the obvious cost savings of developing multi-mission hardware, some experiments need to be flown more than once to provide adequate verification of their results. Decisions regarding reflights must always weigh the value of the additional science against the costs of maintaining the instruments as well as the science teams, which, while often costing less than new hardware development, are significant.

Integration costs: For most Spacelab missions the cost of mission management, testing and integration is approximately 50 to 100 percent of the cost of hardware development. Some of the costs of integration may be reduced for an experiment reflight. Savings may be found in the availability of existing flight support equipment and software, unique integration hardware, and engineering and safety analyses. Typically, the mission management and integration effort begins three to four years prior to the planned launch date.

Post flight data analysis: The post flight data analysis costs depend upon the individuals or institutions performing the analysis and the type of analysis that is required based on the scientific goals of the mission. The cost of data analysis also depends on the number of investigations, the size of the investigation team, and the length and technical complexity of the investigation (e.g., the need for complex computer support, etc.).

Despite these generalizations, it is important to note that for each individual mission, the hardware development costs, the integration costs, data analysis costs, and other related costs, will vary significantly according to the scientific objectives of the mission and the complexity of the technology involved in achieving those objectives. In each case, different science objectives will usually require variations in instrument complements, which in turn may require different methods of integration on the Shuttle.

For example, life science Spacelab missions (which generally use a module to provide a shirt-sleeve environment in which the experiments are performed) have far different instrument complements and Shuttle configuration requirements than astrophysics Spacelab missions (which typically mount instruments in the open Shuttle bay). As such, the total mission costs can vary significantly, perhaps by as much as $50 million or more. It is therefore difficult to define generic Spacelab mission costs in terms of specific hardware, integration, data analysis, or other costs.

The annual mission unique operations budget for Spacelab, Pallet, and Mission Peculiar Support Structure missions which have already flown is:

FY 83	FY 84	FY 85	FY 86	FY 87	FY 88	FY 89
$1.1M	$1.7M	$2.1M	$.4M	*	*	$1.0M

In addition, the Space Network, including TDRSS, provides a generic multi-mission support capability for NASA Earth-orbital missions which are technically compatible. Because this network provides a general purpose support capability, we do not allocate

Network costs on a per mission basis for any NASA missions.

The planned annual mission unique operations budget for each Spacelab, Pallet, and Mission Peculiar Support Structure missions for which a flight date has been requested in the current Space Shuttle manifest is:

FY 90	FY 91	FY 92	FY 93	FY 94
$2.7M	$4.7M	$7.1M	$7.3M	$6.0M

In addition, the Space Network, including TDRSS, provides a generic multi-mission support capability for all NASA Earth-orbital missions which are technically compatible. Because this network provides a general purpose support capability, we do not allocate Network costs on a per mission basis for any NASA mission.

* Post-Challenger - no missions flown

QUESTION 3:

The most recent Mixed Fleet Manifest projects a Shuttle flight rate of 14 flights per year by the mid-1990's. However, previous NASA statements have indicated a goal of 16 flights per year, and the ASRM RFP stipulates a production capacity to support 16 flights per year. At what time would a 16 flights per year rate be achieved?

ANSWER 3:

At present, NASA's plans for the Shuttle flight rate are not specific with regard to rates higher than the 14 flights per year reflected in the January 1989 Mixed Fleet Manifest. It is recognized that in the latter part of the 1990's the assembly and operation of Space Station Freedom, when combined with other payload flight requirements, may create a need for a higher rate, but specific planning for this has been deferred until we have gained more operational experience with the post-Challenger procedures.

In previous statements, we have referred to a steady-state rate of 14 flights per year, with an ability to surge to a 16-per-year rate. The planned ASRM production rate is 14 flight sets per year to meet the STS manifest requirements plus two motors per year for static test firing. The ASRM RFP specified that the production facility be sized to accommodate a potential surge rate of 16 flight sets per year.

QUESTION 4:

What additional resources and facilities (if any) would be required to support a flight rate of 16 flights per year.

ANSWER 4:

In March 1986, NASA established an ad hoc Flight Rate Capability Working Group to determine a realistic projected flight rate.

Based on the assumptions that certain identified enhancements and a four orbiter fleet were available, a maximum sustained flight rate of 14 shuttle flights per year was projected. Additionally, NASA projected that a surge rate of one or possibly even two additional flights was possible, but not sustainable. Current planning for the Shuttle-C, should it be approved, includes up to three Shuttle-C flights per year (in addition to the 14 flight per year shuttle flight rate) without additional facility requirements.

The determination of flight rate capability requires the evaluation of every facet of this complex program, from the recruiting and training of crew members to the deployment of contingency crews to abort landing sites. In order to determine what additional resources and facilities would be required to support a sustained flight rate of 16 per year, NASA would have to recommission the Flight Rate Capability Working Group to evaluate the issue based on recent return-to-flight experience.

QUESTION 5:

What additional resources and facilities (if any) would be required to support a flight rate of 18 flights per year?

ANSWER 5:

In March 1986, NASA established an ad hoc Flight Rate Capability Working Group to determine a realistic projected flight rate. Based on the assumptions that certain identified enhancements and a four orbiter fleet were available, a maximum sustained flight rate of 14 shuttle flights per year was projected. Additionally, NASA projected that a surge rate of one or possibly even two additional shuttle flights was possible, but not sustainable. Current planning for Shuttle-C includes up to three Shuttle-C flights per year (in addition to the 14 flight per year shuttle flight rate) without additional facility requirements.

The determination of flight rate capability requires the evaluation of every facet of this complex program, from the recruiting and training of crew members to the deployment of contingency crews to abort landing sites. As with question 4, NASA cannot enumerate the additional resources required for an 18-flights-per-year rate. It is certain, however, that the answer would differ from the one relating to 16 per year because every increment in the flight rate tends to saturate a different facility or capability, thus, requiring a step increase in capability to satisfy the requirement.

QUESTION 6:

The issue of the reliability of the Shuttle, and confidence in assessment of Shuttle reliability, is central to future space planning. Unofficial estimates of Shuttle reliability suggest that the incidence of catastrophic failure range between one every several dozen missions to one every several hundred missions. These failure rates imply either a high probability of a catastrophic accident within the next several years, or a good chance that the current Shuttle system will not experience another catastrophic failure prior to its retirement in the 2010 time frame. Apart for continuing efforts to enhance the safety of the Shuttle, what can be done to reduce this uncertainty concerning the Shuttle's reliability?

ANSWER 6:

There has been no single comprehensive effort to model Shuttle reliability, since such assessment historically have not been used in the extensive NASA engineering review processes for assurance of reliability of safety. Since the Challenger tragedy, substantial effort has been expended in the determination of the appropriate role for reliability and risk modeling in NASA, and in the Shuttle program in particular. Several successful probabilistic risk assessment (PRA) proof-of-concept studies have been completed on Shuttle subsystems. In addition, many projects are under way to enhance Shuttle risk/reliability program, consistent with NASA policy as defined in NASA Management Instruction 8070.4, Risk Management Policy for Manned Flight Programs. These projects include the enhancement of the hazard analysis process by use of risk criteria in the prioritization of open risk issues, so that resources for risk mitigation, through redesign or other measures, can be allocated to risk drivers and not unduly expended on risks of lesser import; an independent assessment of accident sequence probabilities which has been performed for Galileo, as part of the required nuclear risk assessment for the program; and a critical function audit project which is in process for the main propulsion system, which will include a risk assessment capability.

In order to reduce the uncertainties concerning Shuttle reliability, it is necessary to enhance the structure of the models used in the aforementioned projects, so that additional engineering knowledge may be applied. This in turn requires the application of the resources of Shuttle Program subsystem engineering. Concurrently, data collection efforts should be enhanced to further support such analysis. These measures are being taken; however, if risk/reliability estimate uncertainty reduction is given still higher priority, resources for this process will need to be enhanced, possibly at the expense of mission related activities.

QUESTION 7:

What is your current assessment of best that can be done to reduce the uncertainty concerning Shuttle reliability?

ANSWER 7:

Based upon the uncertainties in the current studies, and the expected improvements from additional modeling of engineering knowledge, it should be possible to reduce the uncertainty to plus and minus factor of two.

QUESTION 8:

In the absence of greater certainty concerning Shuttle reliability, what steps should be taken to hedge against the possibility of a catastrophic failure of the Shuttle prior to completion of Phase I of Space Station Freedom?

ANSWER 8:

To hedge against catastrophic failure of Shuttle prior to completion of Phase I of Space Station Freedom (SSF), the following steps are recommended:

1. Continue efforts to improve reliability through the use of risk criteria for prioritization as the basis for the disposition of risk issues.

2. Continue the intensive system of quality assurance qualification/acceptance testing and engineering review for all Shuttle missions.

QUESTION 9:

Space Station Freedom is currently planned to have an operational lifetime of three decades. Unofficial estimates of the reliability of the Shuttle suggest that the Shuttle might be grounded due to catastrophic failure a number of times over such a period, or that there is a good chance that the Shuttle might experience no failures leading to grounding during such a period. What level of Shuttle reliability, with what range of confidence, is the minimum that can be accepted in order for the Shuttle to be considered the primary logistical support system for Space Station Freedom.

ANSWER 9:

The Space Shuttle must be sufficiently reliable to make it very unlikely that the safety of the space station crew will be threatened at any time. Specific numerical reliability and availability requirements, however, cannot be simply quantified because other factors mitigate some of the risk from Shuttle delays.

For example, the space station will always maintain reserve provisions to support the full crew for at least 150 days without resupply. Five Shuttle resupply missions are planned every year, so these provisions will allow the station to skip at least one routine Shuttle resupply flight.

Also, we are studying the use of expendable launch vehicles (ELVs) for logistics support of the space station. Although ELVs would not transport crews, they could complement and backup the Shuttle in supplying space station, and would also reduce the Space Shuttle workload.

We are also studying the development of an emergency return capability that could evacuate crew members if a serious problem occurred with either the Shuttle or the space station itself.

QUESTION 10:

Development of the Crew Emergency Return Vehicle may require several billion dollars.

a. Are there any considerations that preclude the use of the European Hermes or the Japanese HOPE vehicles in this capacity?

b. What would be the cost and schedule implications of using one or both of these vehicles in this capacity?

ANSWER 10:

a. The Crew Emergency Return Vehicle (CERV) is a space-based, "life boat" concept to provide emergency standby capability which can be readily activated, has long duration on orbit, and can accommodate from two (2) to four (4) crew members.

Hermes is a small space plane planned by the European community for manned sortie missions. During the last half of 1987, NASA and the European Space Agency (ESA) conducted a Hermes/Space Station Freedom Interface Study. The study established that interfacing is possible for visits to Space Station Freedom, if Hermes were to include certain design changes and a docking and berthing system. Hermes, however, does not satisfy several major criteria for an on-orbit rescue vehicle. In order to perform its emergency function, the CERV must be simple, available and reliable. In comparison, the Hermes, which is currently configured for only three (3) crew seats, is relatively complex, has limited life in orbit (12 days), and would require a minimum 90-day processing time.

Japan's HOPE, or H-II Orbiting Plane, is an unmanned space plane concept that is intended, according to Japan's space agency (NASDA) responsible for HOPE development, for the recovery of experimental products from the Space Station and various platforms. While planning for HOPE is under way, it is not an approved program. As planned, HOPE has a four-day orbital life, and will not contain the systems for crew life support or the attendant reliability of a manned vehicle.

b. The purpose of the CERV is to safely return Space Station Freedom crews to Earth in the event of a contingency where the NSTS cannot provide return in the timeframe required. The CERV program, if approved, would cost approximately $1.4 - $2.0 billion (real-year dollars) to develop and would support the Space Station Freedom permanent manned capability (PMC) scheduled for the last quarter of CY 1996.

The Hermes vehicle, which entails an approximately $5 billion program, is not configured to provide continuous storage at Space Station Freedom, and, therefore, it would require extensive redesign and the attendant risk of not providing the required availability or reliability. Hermes is scheduled to be operational in the year 2000, four (4) years after Space Station

Freedom permanent manned capability (PMC). It is not considered possible to accelerate the Hermes program by the four years needed to meet Space Station Freedom requirements in 1996. The preliminary schedule for HOPE requires test flights in 1998, and calls for HOPE to provide support to JEM, Japan's Space Station Freedom module, after the year 2000. Inasmuch as HOPE is not a manned vehicle, usage for rescue of crew members is not considered possible without major redesign. The present schedule for HOPE would not support this redesign in time to support Space Station Freedom permanent manned capability (PMC). It is not known whether Japan will develop the capability for a manned HOPE system, which would result in an increase to its weight, since their H-II launch vehicle, planned as the vehicle to launch HOPE, can only support the present unmanned mass of the HOPE.

QUESTION 11:

The Advanced Solid Rocket Motor is scheduled to be phased into service beginning in 1994, with replacement of the Redesigned Solid Rocket Motor by 1998. NASA studies have suggested that use of the ASRM would reduce the number of Shuttle flights required to assemble Space Station Freedom, as well as eliminate the potential need for expendable launch vehicles to provide logistical support for the station. However, current station planning apparently has not baselined use of the ASRM. At what point will station planning baseline use of the ASRM?

ANSWER 11:

In concert with the benefits of improved margins of safety and reliability, the ASRM could provide additional performance margins and payload lift capabilities for Space Station Freedom assembly and logistics resupply. It is currently in a competitive procurement action with contract award targeted for early April 1989. Following contract award, NASA will be able to commit to an improved Shuttle reliability and performance capability to support Station transportation requirements. A significant performance enhancement would enable the Space Station Freedom program to assess baselining assembly and logistics resupply with an ASRM. When the program achieves the state of maturity where the performance and schedule availability are fully understood, the Space Station Freedom Program will baseline use of the ASRM. Use of expendable launch vehicles for logistics resupply is independent of the ASRM program and will be assessed in future studies.

QUESTION 12:

In addition to the ASRM, other efforts are currently under way to improve the performance of the Shuttle system, such as development of new SSME hardware capable of supporting operations at the 109% power level.

a. What efforts are currently programmed to improve the performance of the Shuttle?

b. What additional efforts have been identified as potentially offering improved Shuttle performance?

c. What level of performance improvement can be anticipated from each of these efforts?

d. What is the development cost, flight hardware procurement cost, and additional cost per flight, associated with each of these efforts?

e. What is the schedule for implementation of these efforts?

f. In addition to the ASRM, what additional efforts, such as the 109 percent SSME, will be included in the baseline Shuttle configuration?

ANSWER 12:

a. The only effort currently programmed to improve the payload capability of the Shuttle (other than the ASRM) is the aerotesting which could provide as much as 1000 pounds of net improvement by the mid-1990's.

b. A program effort to develop candidate improvements to enhance Shuttle performance capability has recently been initiated. A number of candidate improvements such as an upgraded OMS pump-fed engine, composite materials, heads up trajectory design and ET tumble valve removal are being discussed. However, it is too early at this stage in the program to identify a meaningful list of potential improvements with the associated impacts.

c. See above.

d. As indicated above, there are both currently programmed improvements as well as a number of candidate improvements. Aerotesting, which is the only programmed effort other than ASRM at present, will result in development and flight hardware costs of approximately 15 million dollars. This effort should not have any significant impact on cost per flight. In addition, potential improvements, as described above, are emerging, though it is premature to definitively determine possible improvements and associated costs.

e. The aerotesting improvement can be implemented by the mid-1990's.

f. The SSME is currently rated for a maximum thrust of 104 percent rated power level and is tested for short durations at 109 percent for abort purposes. There is no baseline planning to upgrade the SSME for a nominal 109% power level capability.

QUESTION 13:

Each Shuttle orbiter is rated as having a nominal lifetime of 100 flights. At currently projected flight rates of 14 flights per year, this would lead to a requirement to replace the current orbiter fleet in the 2015 time frame. A flight rate of 16 per year would lead to a replacement requirement in about 2010, and flight rates somewhat lower that currently projected would lead to a replacement requirement after 2020.

a. Does NASA currently rate each orbiter with a nominal operating life of 100 flights?

b. What efforts are currently under way to assess the expected operational life of the orbiter fleet?

c. As the orbiter fleet ages, what efforts will be implemented to assess the expected operational life of the orbiter fleet?

ANSWER 13:

a. The orbiter vehicles are certified for at least 100 mission life. The certification program for the hardware was based on demonstrating compliance to the expected number of operating cycles and durations which would be encountered during ground processing and flight for 100 missions. Hardware items which have less than 100 mission life are planned for periodic replacement during the orbiter life cycle (e.g. APU's, fuel cells, OMS engines).

b. A study is underway with Rockwell International and Southwest Research Institute to develop criteria and methodology for a comprehensive approach to assess the effects of operating time and cycles on orbiter subsystem component and materials life.

This is intended to supplement the original certification program by identifying areas where periodic tear down inspections would be warranted to detect incipient hardware degradation, while also showing where demonstrated life could be extended. This activity is expected to be conducted over the next several years, although budget pressures have relegated it to a low priority.

c. The orbiter turnaround processing between missions provides a comprehensive knowledge of hardware integrity. Checkout and inspection requirements are in place to verify the functional capability of the hardware and detect anomalous conditions. Problems occurring during ground and flight operations are assessed relative to life cause factors. This provides insight on expected operational life. The orbiter primary structure is currently inspected on a periodic basis (approximately three-year intervals) in a very detailed manner to detect any adverse effects of flight loads, corrosion, and fatigue. When problems are found, corrective actions are taken to preserve orbiter capability.

APPENDIX 7

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May 19, 1989

The Hon. Bill Nelson
Chairman, Subcommittee on Space Science
and Applications
2321 Rayburn HOB
Washington, DC 20515

Dear Congressman Nelson:

Enclosed is the marked-up version of my April 4, 1989 testimony to your committee. Your transcribers should be commended for their ability in deciphering technical language.

I would like to amplify my testimony on p. 49. I left the impression that the Space Telescope uses RTG's which, since it is in Earth orbit, it does not - it relies on solar cells. I should have stated: "The RTG decay is a problem for delayed deep-space missions such as Galileo and Ulysses, but not for HST."

I would like to correct my faulty memory in my testimony concerning the total ozone mapping. I incorrectly stated (p. 71) that there was another Nimbus ready for launch. The correct statement is that there is a TOMS instrument (upgraded slightly from the Nimbus version) ready to launch, and there has been an U.S.-Soviet agreement to launch that TOMS instrument on a Soviet "METEOR" spacecraft in early 1991. This is not an ideal situation for various technical reasons, but my conclusion remains the same; there is a backup ozone mapper and thus a one year slip in a U.S. TOMS launch is probably not too damaging.

I wish you the best in handling the difficult budget process and I again plead that you not restore any cancelled programs without finding the funds to go with them. I stand behind my conclusion that delaying the space station is the only way to save large amounts of money from NASA without seriously compromising a science program which is attempting to get back on its feet again.

I am also enclosing a color photo of the Dynamics Explorer auroral image which I showed in the session. I would like to have it appended to my written testimony.

Please feel free to call upon me again if I may serve you. You may use this letter as an appendix to the testimony.

Sincerely,

Patricia H. Reiff

PHR/nbc
Encl.: Testimony
Photo

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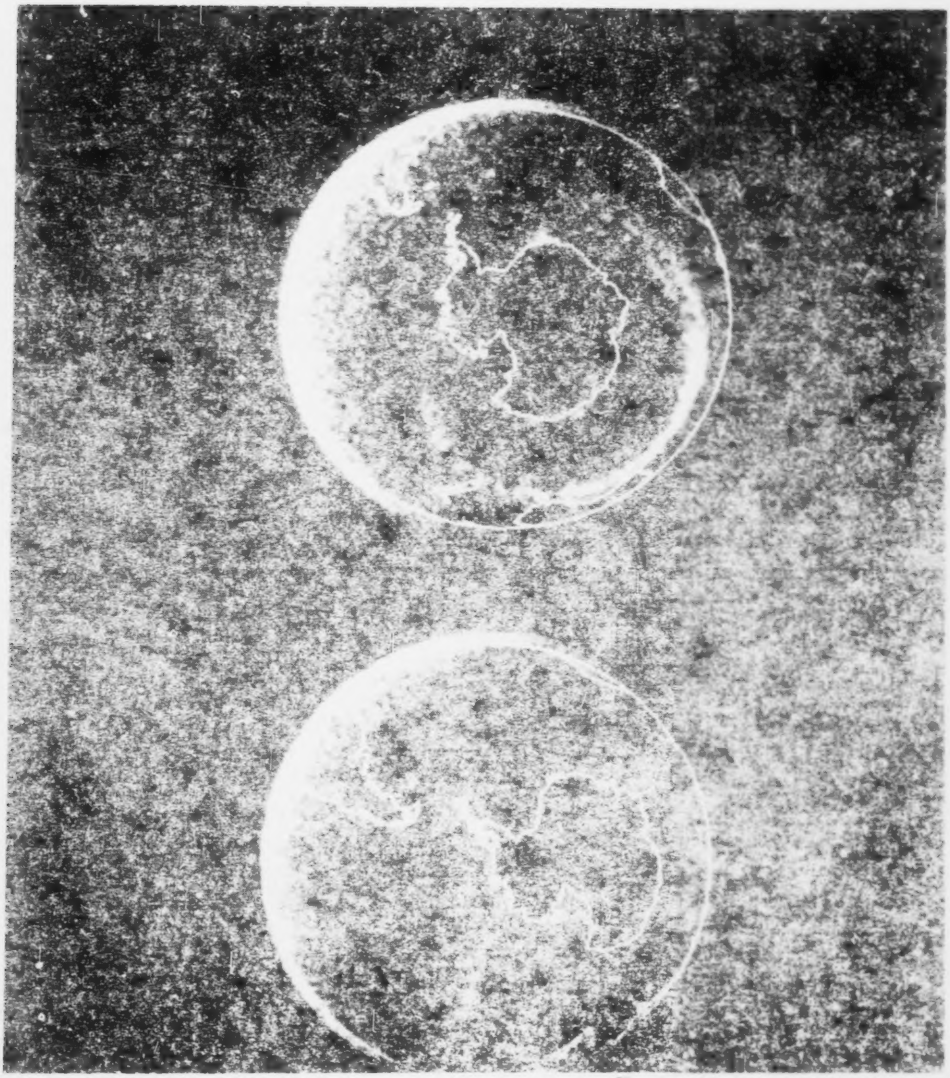

AURORA OVER THE SOUTHERN HEMISPHERE MARCH 14, 1989

This Dynamics Explorer image, taken in ultraviolet light, shows the largest auroral oval ever recorded by this spacecraft. The main auroral belt reaches southern Australia (latitude 37 degrees). This aurora, the result of one of the largest solar flares on record, caused aurora sightings as far south as the Carolinas and Brownsville TX. The lower image shows a more normal auroral belt. (Image courtesy Dr. L. A. Frank, University of Iowa).

APPENDIX 8

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CSP

April 7, 1989

The Honorable Bill Nelson
Chairman, Subcommittee on Space Science and Applications
Suite 2321 Rayburn H.O.B.
Washington, DC 20515

Dear Congressman Nelson:

I very much enjoyed the opportunity to testify before your subcommittee. The members asked very penetrating questions and I hope my responses were appropriate. Your questions about magnetospheric physics were of course especially gratifying to me and I'd be delighted to bring you up to date on some of the exciting new research in my field. I'll also be sending you a copy of the photo of the aurora over Australia. In the meantime I wanted to clarify a couple of the responses that I made to the committee.

When answering the question about TOMS, I may have left the impression that there was another Nimbus available to launch. Unfortunately, that is not the case; the backup possibility is a joint venture with the Russians, which may or may not materialize. Even if it does not, I hope that a one-year delay of TOMS would not be fatal to ozone monitoring. As I mentioned in my written testimony, the TOMS program is very important. I think it is extremely likely that the Earth Observing System (EOS) will get the nod for a "new start" for next year, and the TOMS program would go along with EOS extremely well in a "Mission to Planet Earth" strategy.

When answering your question about why the aurora is a ring and doesn't display its highest intensity at the pole, I should have mentioned that the very energetic solar and galactic particles do indeed cover the entire polar cap. The auroral ring, because it maps to the boundary between field lines which are dipolar and those which extend down deep into the magnetic tail and out into interplanetary space, is a good indicator of the area of possible energetic particle bombardment. Thus, although the aurora itself is generally not energetic enough to cause serious worries for humans, it shows the high latitude limit of the "safe zone". In cases like these, where the auroral ring is extremely large, energetic particles from continuing solar flare activity have access to much lower latitudes than they normally do, and thus could pose a hazard for a mid-latitude (50 or 60 degree) manned mission. In this regard it would be interesting to discover whether the Mir cosmonauts experienced any excessive radiation dosages, or whether they saw any auroral displays.

It is perhaps not surprising that most space scientists are environmentalists. The view from space shows how very small the Earth is in the vastness of the cosmos. We have now visited most of the planets and their moons; there is not another spot in the solar system that can be populated without extensive "terraforming". We must keep this Earth a livable place!

Once again, thanks for giving me the opportunity to testify. I would be delighted to answer any further questions you have at any time. I also have some ideas for a "non-tax" revenue enhancer that I would be pleased to discuss with you at some future date.

Sincerely,

Pat

Patricia H. Reiff

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APPENDIX 9

THE ECONOMIC AND EMPLOYMENT BENEFITS TO THE NATION AND TO EACH STATE OF THE U.S. SPACE PROGRAM

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Prepared for the NASA Alumni League

December 1988
(Revised January 1989)

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EXECUTIVE SUMMARY

This report estimates the private sector economic and employment benefits (disaggregated among 80 industries and 475 occupations) of the U.S. Space Program to the nation, to each state, and to select cities. Nationwide, it finds that FY 1987 NASA procurement expenditures of $8.6 billion had an economic multiplier of 2.1 and created, directly and indirectly:

- o $17.8 billion in total industry sales
- o 210,000 jobs[a]
- o $2 billion in corporate profits
- o $5.6 billion in Federal, state, and local government tax revenues

The economic multipliers vary widely among individual industries, ranging from a high of 5.9 for Electronic Components to a low of 1.3 for Aircraft and Parts (Table Ex.1).

While the jobs created are disproportionately concentrated among Scientists, Engineers, and skilled workers, in absolute terms many more jobs are created for blue collar and lesser skilled labor. Substantial numbers of jobs are created for workers in virtually every industry and every occupation (Table Ex.2).

As expected, the industry and job benefits are concentrated in those states such as California, Texas, and Florida that are the largest direct recipients of NASA program funds. However, every state in the nation benefits significantly from the Space Program, and the total sales and jobs created in each state are shown in Table Ex.3.

A major purpose of this study was to estimate the indirect economic benefits to each state resulting from the U.S. Space Program. For many states these are found to be very high (multipliers exceeding 8 to 1--see Table Ex.4).

Every state is ranked according to the benefits it receives from the NASA program on the basis of three criteria:

- o total (direct plus indirect) economic and employment benefits
- o per capita benefits

---

[a] These are jobs in private industry and do not include NASA employees or other Federal government workers

- the ratio of the total benefits in the state to t received directly from NASA

These criteria allow us to identify the states benef most, both directly and indirectly, from the U.S. Space I shown in Table Ex.5, these "winners" include many states linked to the Space Program, such as New Jersey, Arizona, Illinois, Tennessee, Wisconsin, Michigan, New Hampshire, Carolina.

The individual state impacts of the U.S. Space Progr illustrated by examining the detailed industry and job be Louisiana and Indiana. In Indiana, for example, it is fc every dollar the state receives directly in Space Progran it receives and additional $11 indirectly.

The implications of these results for ambitious U.S. programs and goals during the 1990s are discussed.

The major conclusions of this study are:

- The detailed industry and job benefits of the U.S Program can be reliably estimated by industry anc for the nation and for each state.
- The total (direct plus indirect) economic and em benefits are between two and three times larger t usually assumed, and are much more pervasive thar generally recognized.
- The major beneficiaries--specific industries, occ and states--include many which have heretofore nc linked closely to the Space Program or to NASA pr
- These estimates are critically important for mair enhancing the U.S. Space Program through the rema century.

Extensions of the analysis proposed include:

- Further disaggregation to examine in detail the states other than Indiana and Louisiana.
- Disaggregation below the state level to asses th NASA spending on individual cities and counties
- Estimation of the detailed benefits of the propos and FY 1991 NASA budgets
- Simulation of the benefits of the ambitious U.S. Programs proposed for the 1990s (AIAA, NCS, Ride

Table Ex-1
Economic Multipliers Resulting from 1987 NASA Procurement--Selected Industries

Industry	Multiplier[a]
Electronic Components	5.9
Electric Lighting and Wiring Equipment	4.8
Electric, Gas, and Sanitary Services	4.5
Chemicals and Selected Chemical Products	3.3
Wholesale and Retail Trade	3.2
Paints and Allied Products	2.9
Glass and Glass Products	2.8
Communications, except Radio and Television	2.7
Business Services	2.4
Transportation and Warehousing	2.3
Electrical Transmission Equipment	2.2
AVERAGE, ALL INDUSTRIES	2.1
Petroleum Refining and Related Industries	2.0
Motor Vehicles and Equipment	1.8
Metal Containers	1.7
Engines and Turbines	1.4
Aircraft and Parts	1.3
Miscellaneous Transportation Equipment	1.1

---

[a] Ratio of total to direct output requirements.

Source: Management Information Services, Inc., 1988.

Table Ex.2

Jobs Created by 1987 NASA Procurement Expenditures Within Selected Occupations

Occupation	Jobs
Accountants and Auditors	2,291
Personnel and Training Specialists	609
Aeronautical Engineers	2,750
Chemical Engineers	380
Electrical and Electronics Engineers	4,474
Industrial Engineers	1,848
Mechanical Engineers	2,024
Computer Systems Analysts	931
Statisticians	34
Chemists	340
Geologists and Geodeists	163
Technical Writers	291
Electrical and Electronics Engineering Technicians	2,006
Computer Programmers	750
Tool Programmers	1,581
Computer Operators	1,505
Secretaries	6,784
Bookkeepers and Accounting Clerks	3,212
Janitors and Cleaners	3,016
Heavy Equipment Mechanics	690
Data Processing Equipment Repairers	220
Heating and Air Conditioning Mechanics	390
Millwrights	192
Carpenters	2,294
Electricians	1,525
Tool and Die Makers	1,124
Machinists	3,013
Precision Grinders	130
Sheetmetal Workers	1,295
Photoengravers and Lithographers	78
Photographic Process Machine Operators	147
Welders and Cutters	2,109
Truck Drivers	5,198
Operating Engineers	276
Stock Handlers and Baggers	933
Total, All Occupations*	208,914

*Totals include data for the 435 occupations not listed separately.

Source: Management Information Services, Inc., 1988.

Table Ex.3

1987 Sales and Jobs Created in Each State by the U.S. Space Program

State	Sales		Employment	
	(millions)	(% of US)	(number)	(% of US)
Alabama	$633.9	3.6	7,457	3.6
Alaska	30.2	0.2	180	0.1
Arizona	176.1	1.0	2,111	1.0
Arkansas	68.4	0.4	729	0.3
California	5,219.5	29.3	63,612	30.4
Colorado	379.5	2.1	4,876	2.3
Connecticut	457.4	2.6	5,452	2.6
Delaware	24.6	0.1	249	0.1
Dist. Columbia	57.5	0.3	898	0.4
Florida	996.7	5.6	13,462	6.4
Georgia	228.2	1.3	2,743	1.3
Hawaii	17.9	0.1	257	0.1
Idaho	16.6	0.1	204	0.1
Illinois	420.5	2.4	4,801	2.3
Indiana	263.1	1.5	2,695	1.3
Iowa	72.5	0.4	903	0.4
Kansas	132.6	0.7	1,383	0.7
Kentucky	110.5	0.6	1,165	0.6
Louisiana	426.4	2.4	3,929	1.9
Maine	27.4	0.2	323	0.2
Maryland	756.5	4.3	10,342	5.0
Massachusetts	290.4	1.6	3,719	1.8
Michigan	388.9	2.2	3,727	1.8
Minnesota	126.8	0.7	1,550	0.7
Mississippi	178.7	1.0	1,858	0.9
Missouri	260.5	1.5	2,829	1.4
Montana	15.1	0.1	151	0.1
Nebraska	36.6	0.2	483	0.2
Nevada	24.3	0.1	349	0.2
New Hampshire	44.6	0.3	553	0.3

Table Ex.3 (continued)

1987 Sales and Jobs Created in Each State by the U.S. Space Program

State	Sales (millions)	Sales (% of US)	Employment (number)	Employment (% of US)
New Jersey	385.5	2.2	4,810	2.3
New Mexico	108.1	0.6	1,090	0.5
New York	543.0	3.1	6,728	3.2
North Carolina	174.6	1.0	2,096	1.0
North Dakota	14.4	0.1	152	0.1
Ohio	707.7	4.0	7,264	3.5
Oklahoma	127.2	0.7	1,100	0.5
Oregon	51.0	0.3	614	0.3
Pennsylvania	460.3	2.6	5,111	2.4
Rhode Island	24.4	0.1	298	0.1
South Carolina	82.4	0.5	975	0.5
South Dakota	14.3	0.1	194	0.1
Tennessee	158.9	0.9	1,903	0.9
Texas	1,653.8	9.3	17,094	8.2
Utah	455.9	2.6	5,330	2.6
Vermont	16.0	0.1	195	0.1
Virginia	481.3	2.7	5,962	2.9
Washington	235.9	1.3	2,669	1.3
West Virginia	48.8	0.3	428	0.2
Wisconsin	149.4	0.8	1,736	0.8
Wyoming	23.9	0.1	175	0.1
Total	$17,798.8	-	208,914	-

Source: Management Information Services, Inc.; 1988.

Table Ex.4

Economic Multipliers of the U.S. Space Program for Selected States

	Multiplier[a]
Indiana	12.0 to 1
Michigan	10.9 to 1
Missouri	8.5 to 1
Illinois	8.1 to 1
Kansas	7.2 to 1
Tennessee	7.0 to 1
Oregon	6.3 to 1
North Carolina	5.8 to 1
Wisconsin	5.5 to 1
New York	4.6 to 1
Ohio	4.0 to 1
Mississippi	2.5 to 1
New Jersey	2.2 to 1
Texas	2.0 to 1
California	1.7 to 1
Alabama	1.4 to 1
Florida	1.3 to 1

---

[a] Ratio of total (direct plus indirect) economic benefits to direct economic benefits.

Source: Management Information Services, Inc., 1988.

Table Ex.5

Categorization of the States Benefiting Most From the U.S. Space Program

Category A

Major Prime Contract Award States

- California
- Texas
- Florida
- Maryland
- Alabama
- Louisiana
- Utah
- Virginia
- Connecticut
- Ohio

Category B

States Benefiting the Most (Indirectly) From the U.S. Space Program

- Colorado
- New Jersey
- New York
- Arizona
- Mississippi
- Kansas
- Indiana
- Illinois
- Michigan
- Tennessee
- Washington
- Massachusetts
- Missouri
- Wisconsin
- New Hampshire
- New Mexico
- Georgia
- District of Columbia
- North Carolina

Source: Management Information Services, Inc., 1988

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I. INTRODUCTION

The MISI analysis presented here shows the direct and indirect economic benefits of the NASA Program to each state and to select cities. Specifically, the analysis includes:

- The total economic benefits--increase in economic product--to each state and created by spending on NASA programs
- The industry sales, industry profits, and total employment created in each state and city by the U.S. Space Program
- The total Federal, state, and local government tax revenues generated the NASA programs
- For each state, detailed estimates showing:
  - sales, profits, and jobs created within 80 all-inclusive industries
  - jobs created within 475 all-inclusive occupations
  - increases generated in personal incomes, wages, and salaries
  - multiplier of direct NASA expenditures to total and indirect economic benefits generated.
- Analysis of the relative benefits for key industries, occupations, and R&D sectors of spending on NASA programs

This type of analysis, while based on well established and validated economic methodology, has never before been applied to the U.S. Space Program or to the NASA budget. The findings of this study are crucial for emphasizing the total (direct plus indirect) economic benefits of NASA Programs to the nation as a whole and to individual state and cities, in defending NASA budget requests, and in justifying increased Federal spending for an ambitious Space Program during the 1990s.

In terms of maxima/minima theory, while not sufficient to guarantee funding of an ambitious U.S. space program over the next decade, the analysis herein is absolutely necessary.

II. TRADITIONAL ECONOMIC RATIONALE FOR THE SPACE PROGRAM

Over the years advocates of the Space Program have identified several types of economic benefits of the U.S. Space Program:

- o public goods.
- o spin-offs.
- o R & D support.
- o creation of new space industries.

Public Goods

Public goods are commodities which only the government can provide in sufficient quantity, since their benefits cannot be captured by private investors in the form of profit, and they remain underproduced unless the government intervenes. For the Space Program these include knowledge gained about the universe and it's origins, information on the characteristics and the history of the earth and solar system, and related basic scientific knowledge.

Spin-offs

Spin-offs are those technologically advanced products and processes developed for the Space Program which ultimately find productive uses in other areas--areas often unrelated to space exploration. These include photovoltaics, advances in aerodynamic design, enhanced telecommunications systems, breakthroughs in microelectronics, improved chemical processes, and so forth.

Research and Development Support

The Space Program enhances the nation's technology base and that of specific industries, and Program advocates argue that it is vital to the technological competitiveness of U.S. industry. Studies have shown that investments in NASA R & D have a return of between five and ten to one over a 25 year horizon, and few doubt the importance of R & D programs for the U.S. economy.

Creation of New Space-Based Industries

Advocates of ambitious space programs emphasize the potential for creating new space-based industries, including private launch services, materials processing in space and related applications of a microgravity environment, remote imaging, infrastructure development, and so forth. Obviously, without a strong U.S. government Space Program, development of these new industries will be delayed and opportunities lost to other nations.

III. THE DIRECT AND INDIRECT ECONOMIC AND EMPLOYMENT BENEFITS OF EXPENDITURES ON THE SPACE PROGRAM

Here we estimate the following benefits of FY 1987 NASA procurement expenditures:

- direct and indirect.
- economic.
- employment.
- national.
- state-specific.

Direct and Indirect

The benefits estimated here include those resulting from the initial procurement expenditures as well as those generated indirectly throughout the economy by the expenditures. Where appropriate, the multipliers (ratio of total benefits to direct benefits) are computed.

Economic

The benefits to each of 80 all-inclusive two-digit SIC industries are estimated. The benefits are the increased output, sales, and profits generated by the Space Program expenditures.

Employment

The total number of jobs created in each of the 80 industries and in each of 475 all-inclusive occupations is estimated. The job data pertain to full-time equivalent (FTE) person-years.

National

Output, sales, profits, and employment are estimated for each industry at the national level, and for each occupation the total number of jobs created nationwide is derived.

State-specific

Output, sales, profits, and employment are estimated for each industry at the state level, for each occupation the total number of jobs created within every state is derived, and the tax revenues generated in the state are computed.

IV. THE MISI APPROACH: ESTIMATING THE TOTAL (DIRECT PLUS INDIRECT) EFFECTS

The economic and employment effects of the NASA programs were computed using the Management Information Services, Inc. data base and information system. A simplified version of the MISI model is illustrated in Figure IV-1, and the specification of the NASA budget simulations is shown in Figure IV-2.

The first step is the translation of expenditures for a program or set of programs into per unit output requirements from every industry in the economy. This is determined by four major factors: 1) the state of technology, 2) the distribution of expenditures, 3) the specific program configuration, and 4) the direct industry requirements structure. While the model contains 500 industries, in the work conducted here an 80-order industry scheme was used.

Second, the direct output requirements of every industry affected as a result of expenditures on the program are estimated. These direct requirements show, proportionately, how much an industry must purchase from every other industry to produce one unit of output.

Direct requirements, however, give rise to subsequent rounds of indirect requirements. For example, steel mills require electricity to produce steel. But an electric utility requires turbines from a factory to produce electricity. The factory requires steel from steel mills to produce turbines, and the steel mill requires more electricity, . . ., and so on.

The latter are the indirect requirements. The sum of the direct plus the indirect requirements represents the total output requirements from an industry necessary to produce one unit of output. Economic input-output (I-O) techniques allow us to compute the direct as well as the indirect production requirements, and these total requirements are represented by the "inverse" equations in the model. The ratio of the total requirements to the direct requirements is called the input-output multiplier.

Thus, in the third step in the model the direct industry output requirements are converted into total output requirements from every industry by means of the input-output inverse equations. These equations show not only the direct requirements, but also the second, third, fourth, . . ., nth round indirect industry and service sector requirements resulting from expenditures on the Space program.

Next, the total output requirements from each industry are used to compute sales volumes, profits, and value added for each industry. Then, using data on manhours, labor requirements, and productivity, employment requirements within each industry are estimated. This allows computation of the total number of jobs created within each industry.

The next step requires the conversion of total employment requirements by industry into job requirements for specific occupations and skills. To accomplish this, MISI utilizes data on the occupational composition of the labor force within each industry and estimates job requirements for 475 specific occupations encompassing the entire U.S. labor force. This permits estimation of the impact of the program on jobs for specific occupations and on skills, education, and training requirements.

Utilizing the modeling approach outlined above, MISI estimated the effects on employment, personal income, corporate sales and profits, and government tax revenues in the United States and in each state. Estimates were then developed for detailed industries and occupations. The results of this analysis serve as the baseline and represent comprehensive and detailed estimates of the national and statewide economic benefits of expenditures on the U.S. Space program. For detailed analysis we selected two states: Indiana and Louisiana.

The next step in the analysis conducted here entailed assessing the economic impact on specific cities--Metroplitan Statistical Areas (MSAs). The MISI approach permits disaggregation to the level of most U.S. MSAs and, if desired, to the county level.

Empirically, the basis of the sub-state estimates is the Regional Input-Output Modeling System (RIMS II) developed by the U.S. Commerce Department's Bureau of Economic Analysis (BEA) over the past two decades.

RIMS II is based on economic input-output analysis which shows, for each industry, industrial distributions of inputs purchased and outputs sold. A typical input-output table in RIMS II is constructed primarily from two sources: 1) BEA's national I-O table, which shows the input and the output structures of more than 500 U.S. industries, and 2) BEA's four-digit Standard Industrial Classification (SIC) county wage-and-salary data, which were used to adjust the national I-O table to show the Rochester MSA's industrial structure and trading patterns.

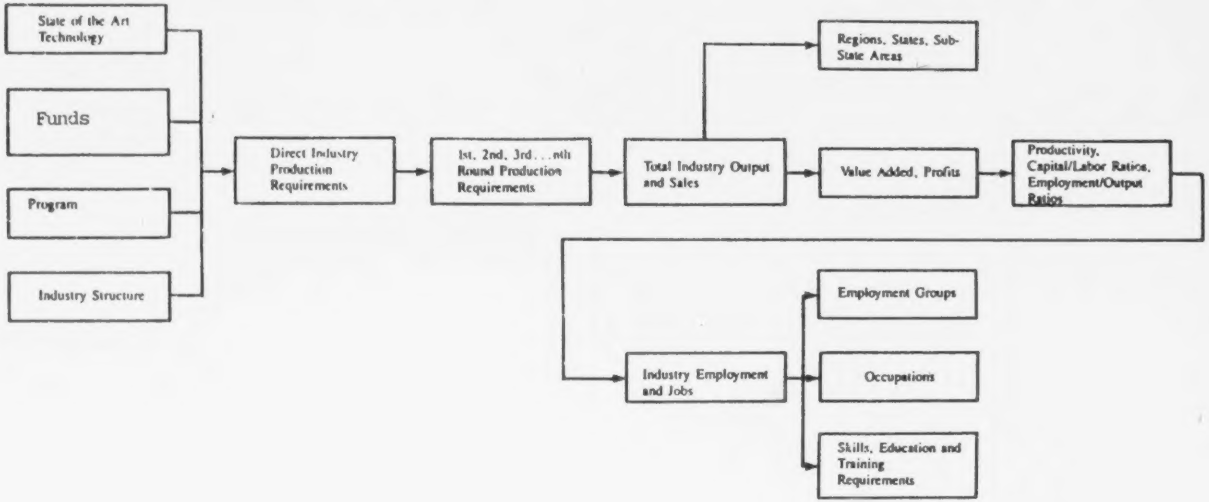
The main data sources for RIMS II permit economic impacts to be estimated for any region composed of one or more counties and for any industry in the national I-O table. RIMS II can be used to estimate the impacts of project and program expenditures by industry on regional output (gross receipts or sales), earnings (the sum of wages and salaries, proprietors' income, and other labor income, less employer contributions to private pension and welfare funds), and employment. The use of the RIMS II methodology has been validated in independent studies over the past two decades.

For the MSAs we were further interested in estimating the impact on requirements for specific occupations. To accomplish this we utilized the MISI occupation-by-industry matrix, the coefficients of which show the percent distribution of occupational employment among all industries. The 80-by-475 matrix was developed from the 1983

Current Population Survey, and was aggregated to 39 industries to conform to the RIMS II industry aggregation.

Figure VI-1

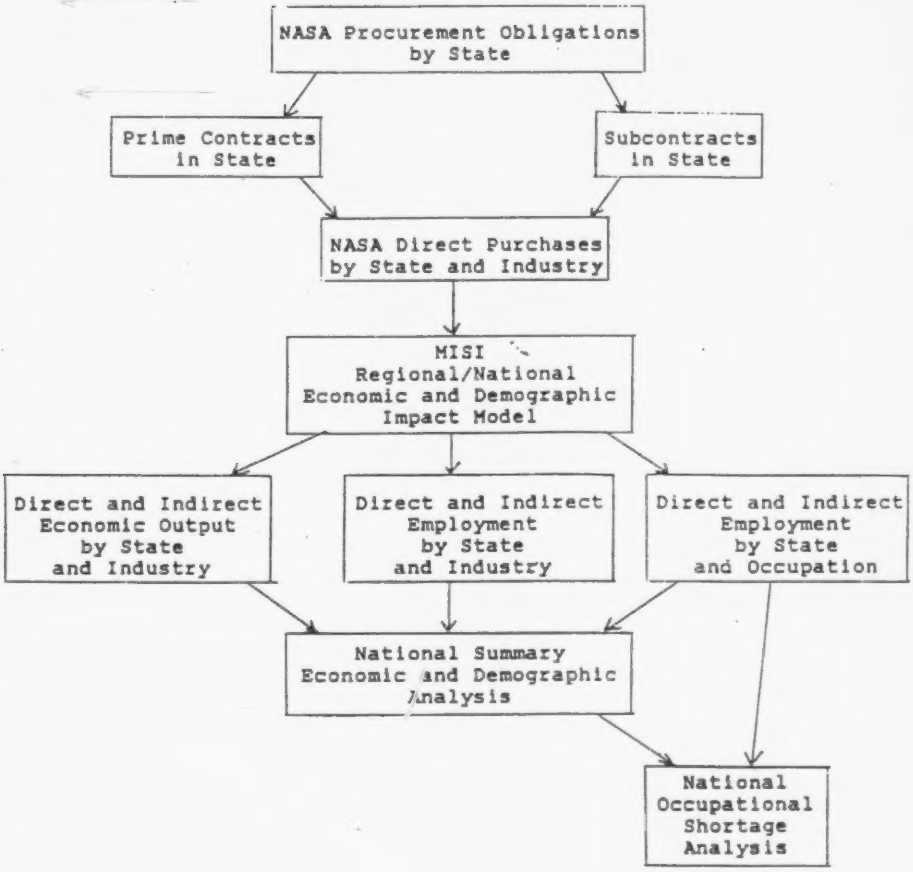
Estimating the Economic and Employment Effects of the U.S. Space Program


State of the Art Technology
Funds
Program
Industry Structure
Direct Industry Production Requirements
Ist, 2nd, 3rd ... nth Round Production Requirements
Total Industry Output and Sales
Regions, States, Sub-State Areas
Value Added, Profits
Productivity, Capital/Labor Ratios, Employment/Output Ratios
Industry Employment and Jobs
Employment Groups
Occupations
Skills, Education and Training Requirements

Source: Management Information Services, Inc., 1988

Figure IV.2

MISI National and Regional Analysis of the
Impacts of NASA Procurements


NASA Procurement Obligations by State
Prime Contracts in State
Subcontracts in State
NASA Direct Purchases by State and Industry
MISI Regional/National Economic and Demographic Impact Model
Direct and Indirect Economic Output by State and Industry
Direct and Indirect Employment by State and Industry
Direct and Indirect Employment by State and Occupation
National Summary Economic and Demographic Analysis
National Occupational Shortage Analysis

Source: Management Information ~~Services,~~ Inc., 1988

V. BENEFITS AT THE NATIONAL LEVEL

We first wish to determine the total (direct plus indirect) economic and employment impact at the national level of expenditures on the U.S. Space program. We simulated the effects of the FY 1987 NASA procurement awards ($8.6 billion--see Table V.1) on sales, earnings, profits, and employment within 80 all-inclusive industries.

These impacts at the national level are summarized in Table V.2 This table shows that in 1987 the NASA procurement of $8.7 billion:

- o generated $17.8 billion in total industry sales.
- o had a multiplier effect on the economy of 2.1.
- o created 208,000 jobs.
- o created $2.0 billion in total industry profits.
- o generated $5.6 billion in Federal, state, and local government tax revenues.

The total sales generated within each industry are shown in Table V.3, and these industries are ranked in Table V.4. As expected, the largest total impacts of NASA procurement are concentrated in Aircraft and Parts, Ordnance and Accessories, Radio, T.V., and Communications Equipment, and related industries. However, it is instructive to examine the individual multipliers for each industry--these are shown for selected industries in Table V.5.

The data in Table V.5 show that, per dollar of direct procurement expenditure, NASA programs will result in widely varying indirect effects among industries. In 1987 these ranged from indirect multipliers as high as nearly six for Electronic Components, five for Electric Lighting and Wiring Equipment, and three for Chemical Products, to lows near two for Motor Vehicles and Equipment and near one for Engines and Turbines and Aircraft and Parts. In other words, the 1987 NASA procurement budget created, indirectly, nearly five dollars in sales in Electronic Components for every dollar directly procured in that industry, while it created, indirectly, only about 30 cents of sales in the Aircraft and Parts industry for every direct dollar of procurement in that industry.

This result is not surprising. Aircraft and motor vehicles are final products whose components do not enter into the production of other commodities, whereas electrical and electronic equipment and chemicals are products required in the production of most other goods.

This illustrates why it is critical, in assessing the impact of the U.S. Space program, to examine the total impact on the economy, not just the direct procurement expenditures. As discussed below, similar relationships exist between direct and indirect effects, and the consequent multipliers, at the state and the MSA levels.

Table V.6 shows the total employment created in each private sector industry by by 1987 NASA procurement expenditures.[a] The data here illustrate that the distribution of jobs created by industry differs in important respects from the distribution of sales shown in Table V.3. Thus, while large numbers of jobs are created in industries such as Aircraft, Ordnance, Business Services, and Communications Equipment where the generated output requirements are large, employment of equal magnitude is also created in service industries such as Wholesale and Retail Trade, Transportation, Warehousing, Restaurants, and Hotels.

Employment created in these latter industries is large because they are very labor intensive and have low capital labor ratios and low productivity. Because of these factors the types of jobs created in these industries is relatively low skilled and pays relatively low wages.

Nevertheless, it is important to note that NASA procurement spending generates large numbers of jobs in industries not usually associated with the Space Program or the aerospace sector, and that workers employed in these industries have an important stake in the U.S. Space Program--even though they are unaware of it. In fact, as Table V.6 shows, 1987 NASA procurement spending created more jobs in Wholesale and Retail Trade than it did in the Communications Equipment industry, and it generated more employment in Transportation and Warehousing than in the Electronic Components industry.

Table V.7 shows the employment created by NASA procurement disaggregated among major occupational groups, and Table V.8 further disaggregates this employment among 115 occupations selected from the 475 occupations for which job requirements were estimated. These tables show that, as expected, the jobs created are disproportionately for technical, skilled, and specialized occupations. Thus, 1987 NASA procurement spending created jobs for 14,000 Engineers (seven percent of total employment created), including 2,800 Aeronautical engineers (4.5 percent of the total employed in private industry), 4,500 Electrical Engineers (1.2 percent of the total employed in private industry), 2,700 Accountants, 340 Chemists, 1,000 Lawyers, 900 Designers, 4,000 Engineering Technicians, 900 Computer Systems Analysts, 1,800 Industrial Machinery Repairers, 2,300 Carpenters, 1,300 Sheetmetal Workers, 3,000 Machinists, and 2,100 Welders.

However, Tables V.7 and V.8 also demonstrate that the Space Program generates substantial jobs for virtually all categories of workers. In fact, the 1987 NASA procurement budget created more jobs (3,200) for Bookkeepers than for Aeronautical Engineers, it created more jobs (6,800) for Secretaries than for Electrical Engineers, more jobs (400) for Personnel and Labor Relations Workers than for Chemists, more jobs (2,500) for Cashiers than for Accountants, more jobs for Shipping Clerks (1,100) than for Designers, more jobs (1,200) for Guards than for Computer Systems Analysts, more jobs (5,200) for Truck Drivers than for Machinists, and more jobs for Janitors (3,000) than for Welders.

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[a] These are jobs in private industry and do not include NASA employees or other Federal government workers

This again illustrates the pervasive nature of the economic and employment impacts of the Space Program.

Table V.1

Summary of NASA Procurement Obligations, 1987

	Amount (millions)	Percent	
Total	$ 8,609.8		100
Business Firms	6,540.5	100	76
Rockwell International Corp. Downey, CA	1,610.2	25	
Martin Marietta Corp. New Orleans, LA	325.9	5	
Lockheed Space Operations Co. Kennedy Space Center, FL	323.3	5	
Morton Thiokol Inc. Brigham City, UT	286.0	4	
McDonnell Douglas Corp. Huntington Beach, CA	285.0	4	
Educational & Nonprofit	434.5	100	5
Stanford University Stanford, CA	23.2	5	
Assn. Univ. Research & Astron. Baltimore, MD	17.7	4	
University California (Berkley) Berkley, CA	13.5	3	
National Academy of Sciences Washington, DC	13.3	3	
Draper Charles Stark Lab Inc. Cambridge, MA	13.2	3	
Jet Propulsion Laboratory	1,005.6	100	12
Subcontracts	571.1	57	
Other Government Agencies	594.9	100	7
Air Force	281.7	47	
Treasury Department	181.0	30	
Outside U.S.	34.1	-	-

Source: Management Information Services, Inc., 1988

Table V.2
Overview of the Economic Benefits of
FY 1987 NASA Procurement Expenditures

Procurement Expenditures (millions)	$8,576
Total Sales Generated (millions)	$17,799
Economic Multiplier	2.1
Total Jobs Created	208,000
Total Profits Generated (millions)	$1,993
Total Federal, State, and Local Government Tax Revenues Generated (millions)	$5,589

Source: Management Information Services, Inc., 1988

Table V.3

Total Impact of 1987 NASA Procurement Expenditures on Output by Industry

Industry Title	Sales (millions)
Livestock & livestock products	$29.6
Other agricultural products	88.9
Forestry & fishery products	10.8
Agricultural, forestry & fishery services	11.7
Iron & ferroalloy ores mining	18.4
Nonferrous metal ores mining	37.9
Coal mining	77.7
Crude petroleum & natural gas	700.6
Stone & clay mining & quarrying	20.0
Chemical & fertilizer mineral mining	11.9
New construction	240.7
Maintenance & repair construction	508.9
Ordnance & accessories	1,793.4
Food & kindred products	93.4
Tobacco manufactures	0.0
Broad & narrow fabrics, yarn & thread mills	64.9
Miscellaneous textile goods & floor coverings	16.8
Apparel	47.1
Miscellaneous fabricated textile products	18.4
Lumber & wood products, exc. containers	86.2
Wood containers	3.7
Household furniture	11.0
Other furniture & fixtures	8.8
Paper & allied products	109.8
Paperboard containers & boxes	40.9
Printing & publishing	185.1
Chemicals & selected chemical products	279.8
Plastics & synthetic materials	89.7
Drugs, cleaning & toilet preparations	34.1
Paints & allied proucts	26.2
Petroleum refining & related industries	781.0
Rubber & miscellaneous plastics products	210.3
Leather tanning & finishing	1.3
Footwear & other leather products	3.6
Glass & glass products	24.6
Stone & clay products	87.8
Primary iron & steel manufacturing	410.4
Primary nonferrous metals manufacturing	465.5
Metal containers	15.0
Heating, fabricated metal products	146.0
Screw machine products & stampings	113.7
Other fabricated metal products	176.6

Table V.3 (continued)

Total Impact of 1987 NASA Procurement Expenditures on Output by Industry

Industry Title	Sales (millions)
Engines & turbines	120.4
Farm & garden machinery	7.7
Construction & mining machinery	36.4
Materials handling machinery	23.6
Metalworking machinery	84.9
Special industry machinery	15.7
General industrial machinery	126.1
Miscellaneous machinery, except electrical	140.6
Office, computing, & accounting machines	158.4
Service industry machines	26.2
Electrical transmission equipment	151.8
Household appliances	15.6
Electric lighting & wiring equipment	43.3
Radio, TV & communication equipment	1,073.0
Electronic components	503.3
Miscellaneous electrical machinery	34.6
Motor vehicles & equipment	250.1
Aircraft & parts	2,827.1
Other transportation equipment	375.3
Professional & scientific supplies	103.4
Optical & photographic equipment	101.4
Miscellaneous manufacturing	27.5
Transportation & warehousing	785.4
Communications, except radio & TV	206.6
Radio & TV broadcasting	48.2
Electric, gas, & sanitary services	612.3
Wholesale & retail trade	668.6
Finance & insurance	210.3
Real estate & rental	321.7
Hotels & personal services	142.9
Business services	923.6
Eating & drinking places	187.6
Automobile repair & service	64.1
Amusements	43.7
Health & educational & nonprofit	60.4
Federal government enterprises	77.0
State & local government enterprises	97.6
Total	$17,798.8

Source: Management Information Services, Inc.; 1988.

Table V.4

Total Impact of 1987 NASA Procurement Expenditures Ranked by Industry

Rank	Industry Title	Percent of US
1	Aircraft & parts	15.9
2	Ordnance & accessories	10.1
3	Radio, TV & communication equipment	6.0
4	Business services	5.2
5	Transportation & warehousing	4.4
6	Petroleum refining & related industries	4.4
7	Crude petroleum & natural gas	3.9
8	Wholesale & retail trade	3.8
9	Electric, gas, & sanitary services	3.4
10	Maintenance & repair construction	2.9
11	Electronic components	2.8
12	Primary nonferrous metals manufacturing	2.6
13	Primary iron & steel manufacturing	2.3
14	Other transportation equipment	2.1
15	Real estate & rental	1.8
16	Chemicals & selected chemical products	1.6
17	Motor vehicles & equipment	1.4
18	New construction	1.4
19	Rubber & miscellaneous plastics products	1.2
20	Finance & insurance	1.2
21	Communications, except radio & TV	1.2
22	Eating & drinking places	1.1
23	Printing & publishing	1.0
24	Other fabricated metal products	1.0
25	Office, computing, & accounting machines	0.9
26	Electrical transmission equipment	0.9
27	Heating, fabricated metal products	0.8
28	Hotels & personal services	0.8
29	Miscellaneous machinery, except electrical	0.8
30	General industrial machinery	0.7
	Total	87.4

Source: Management Information Services, Inc.; 1988.

Table V.5
Indirect Economic Multipliers Resulting from 1987 NASA Procurement--Selected Industries

Industry	Multiplier[a]
Electronic Components	5.9
Electric Lighting and Wiring Equipment	4.8
Electric, Gas, and Sanitary Services	4.5
Chemicals and Selected Chemical Products	3.3
Wholesale and Retail Trade	3.2
Paints and Allied Products	2.9
Glass and Glass Products	2.8
Communications, except Radio and Television	2.7
Business Services	2.4
Transportation and Warehousing	2.3
Electrical Transmission Equipment	2.2
AVERAGE, ALL INDUSTRIES	2.1
Petroleum Refining and Related Industries	2.0
Motor Vehicles and Equipment	1.8
Metal Containers	1.7
Engines and Turbines	1.4
Aircraft and Parts	1.3
Miscellaneous Transportation Equipment	1.1

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[a] Ratio of total to direct output requirements.

Source: Management Information Services, Inc., 1988.

Table V.6

Employment Created in Each Industry by 1987 NASA Procurement Expenditures

Industry Title	Employment
Livestock & livestock products	374
Other agricultural products	2,098
Forestry & fishery products	94
Agricultural, forestry & fishery services	498
Iron & ferroalloy ores mining	115
Nonferrous metal ores mining	390
Coal mining	529
Crude petroleum & natural gas	1,643
Stone & clay mining & quarrying	263
Chemical & fertilizer mineral mining	72
New construction	3,431
Maintenance & repair construction	6,604
Ordnance & accessories	16,749
Food & kindred products	504
Tobacco manufactures	0
Broad & narrow fabrics, yarn & thread mills	741
Miscellaneous textile goods & floor coverings	131
Apparel	1,070
Miscellaneous fabricated textile products	326
Lumber & wood products, exc. containers	1,010
Wood containers	70
Household furniture	183
Other furniture & fixtures	140
Paper & allied products	689
Paperboard containers & boxes	388
Printing & publishing	2,731
Chemicals & selected chemical products	1,521
Plastics & synthetic materials	469
Drugs, cleaning & toilet preparations	220
Paints & allied proucts	177
Petroleum refining & related industries	815
Rubber & miscellaneous plastics products	2,502
Leather tanning & finishing	13
Footwear & other leather products	84
Glass & glass products	312
Stone & clay products	1,010
Primary iron & steel manufacturing	2,828
Primary nonferrous metals manufacturing	3,269
Metal containers	84
Heating, fabricated metal products	2,114
Screw machine products & stampings	1,335
Other fabricated metal products	2,172

Table V.6 (continued)

Employment Created in Each Industry by 1987 NASA Procurement Expenditures

Industry Title	Employment
Engines & turbines	1,065
Farm & garden machinery	68
Construction & mining machinery	286
Materials handling machinery	351
Metalworking machinery	1,243
Special industry machinery	199
General industrial machinery	1,379
Miscellaneous machinery, except electrical	2,489
Office, computing, & accounting machines	1,961
Service industry machines	213
Electrical transmission equipment	2,324
Household appliances	150
Electric lighting & wiring equipment	552
Radio, TV & communication equipment	12,197
Electronic components	7,906
Miscellaneous electrical machinery	417
Motor vehicles & equipment	1,233
Aircraft & parts	27,217
Other transportation equipment	5,002
Professional & scientific supplies	1,829
Optical & photographic equipment	1,046
Miscellaneous manufacturing	420
Transportation & warehousing	10,832
Communications, except radio & TV	2,181
Radio & TV broadcasting	652
Electric, gas, & sanitary services	2,108
Wholesale & retail trade	20,705
Finance & insurance	2,664
Real estate & rental	769
Hotels & personal services	6,113
Business services	19,013
Eating & drinking places	6,215
Automobile repair & service	776
Amusements	980
Health & educational & nonprofit	1,900
Federal government enterprises	2,218
State & local government enterprises	2,472
Total	208,914

Source: Management Information Services, Inc.; 1988.

Table V.7

Jobs Created by 1987 NASA Procurement Expenditures -- Major Occupational Groups

Major Occupational Category	Jobs
Managerial and Professional Specialty Occupations	
Executive, administrative, and managerial occupations	23,522
Professional specialty occupations	27,480
Technical, Sales, and Administrative Support Occupations	
Technicians and related support occupations	8,801
Sales occupations	16,145
Administrative support occupations, including clerical	30,857
Service Occupations	
Protective service occupations	1,740
Service occupations, except protective	12,624
Farming, Forestry, and Fishing Occupations	
Farm operators and managers	1,230
Other agricultural and related occupations	1,543
Forestry and logging occupations	214
Fishers, hunters, and trappers	46
Precision Production, Craft, and Repair Occupations	
Mechanics and repairers	11,022
Construction trades	8,684
Extractive occupations	782
Precision production occupations	18,173
Operators, Fabricators, and Laborers	
Machine operators, assemblers, and inspectors	28,466
Transportation and material moving occupations	9,909
Handlers, equipment cleaners, helpers, and laborers	7,677
Total	208,914

Source: Management Information Services, Inc.; 1988.

Table V.8

Jobs Created by 1987 NASA Procurement Expenditures Within Selected Occupations

Occupation	Jobs
Financial Managers	606
Accountants and Auditors	2,291
Management Analysts	309
Personnel and Training Specialists	609
Buyers, Wholesale and Retail Trade	271
Inspectors, Except Construction	135
Architects	156
Metallurgical Engineers	286
Aeronautical Engineers	2,750
Chemical Engineers	380
Electrical and Electronics Engineers	4,474
Industrial Engineers	1,848
Mechanical Engineers	2,024
Surveyors	40
Computer Systems Analysts	931
Statisticians	34
Chemists	340
Geologists and Geodeists	163
Biological and Life Scientists	11
Registered Nurses	343
Pharmacists	151
Economists	279
Psychologists	94
Lawyers	970
Technical Writers	291
Designers	941
Photographers	219
Public Relations Specialists	283
Clinical Laboratory Technicians	40
Electrical and Electronics Engineering Technicians	2,006
Drafting Occupations	1,029
Computer Programmers	750
Tool Programmers	1,581
Sales Engineers	65
Sales Representatives	2,897
Cashiers	2,532
Supervisors, Financial Records	156
Computer Operators	1,505
Secretaries	6,784
Receptionists	595

Source: Management Information Services, Inc., 1988.

Table V.8 (Continued)

Occupation	Jobs
Personnel Clerks	138
Bookkeepers and Accounting Clerks	3,212
Payroll Clerks	605
Telephone Operators	254
Dispatchers	293
Production Coordinators	1,155
Shipping and Receiving Clerks	1,162
Weighers and Checkers	259
General Office Clerks	1,197
Proofreaders	33
Supervisors, Guards	123
Kitchen Workers	179
Janitors and Cleaners	3,016
Transportation Attendants	192
Horticultural Specialty Farmers	6
Farm Workers	983
Graders and Sorters	24
Timber Cutting and Logging Occupations	191
Automobile Mechanics	860
Bus and Truck Engine Mechanics	618
Small Engine Repairers	151
Heavy Equipment Mechanics	690
Machinery Maintenance Occupations	69
Data Processing Equipment Repairers	220
Telephone Installers	923
Miscellaneous Electronic Equipment Repairers	203
Heating and Air Conditioning Mechanics	390
Mechanical Control Repairers	68
Millwrights	192
Brickmasons and Stonemasons	251
Carpenters	2,294
Electricians	1,525
Glaziers	79
Structural Metal Workers	152
Supervisors, Extractive Occupations	208
Explosives Workers	118
Mining Machine Operators	107
Miscellaneous Mining Occupations	141
Tool and Die Makers	1,124
Machinists	3,013

Source: Management Information Services, Inc., 1988.

Table V.8 (Continued)

Occupation	Jobs
Precision Grinders	130
Sheetmetal Workers	1,295
Upholsterers	117
Patternmakers	27
Electrical Equipment Assemblers	1,611
Inspectors and Testers	1,414
Water and Sewage Treatment Plant Operators	114
Drilling Machine Operators	385
Forging Machine Operators	60
Metal Plating Machine Operators	321
Sawing Machine Operators	147
Photoengravers and Lithographers	78
Textile Sewing Machine Operators	930
Packaging and Filling Machine Operators	840
Separating Machine Operators	113
Crushing and Grinding Machine Operators	62
Photographic Process Machine Operators	147
Welders and Cutters	2,109
Assemblers	5,987
Production Inspectors and Examiners	3,237
Truck Drivers	5,198
Parking Lot Attendants	56
Locomotive Operating Occupations	170
Sailors and Deckhands	38
Operating Engineers	276
Hoist and Winch Operators	70
Crane and Tower Operators	423
Excavating and Loading Machine Operators	135
Grader, Dozer, and Scraper Operators	166
Miscellaneous Material Moving Equipment Operators	351
Helpers, Construction Trades	238
Helpers, Extractive Occupations	16
Construction Laborers	891
Stevedores	87
Stock Handlers and Baggers	933
Total, All Occupations*	208,914

*Totals include data for the 360 occupations not listed separately.

Source: Management Information Services, Inc., 1988.

VI. THE BENEFITS TO EACH STATE

One of the more important questions about the economic effects of the Space Program that must be *resolved is how these benefits are* distributed among the states. Obviously, the states of Florida, Alabama, and Texas contain major NASA facilities and benefit substantially from Agency programs, and so also does California, due to the concentration of the aerospace industry in the southern part of the state. But how are the indirect economic benefits of the NASA programs distributed among these and other states? Does the U.S. Space program have significant effects on most states or are the benefits concentrated in only a relatively few? These types of questions have not heretofore been adequately answered, and they are the focus of this chapter.

VI.A Distribution of the Benefits Among States

The FY 1987 NASA procurement awards classified by type of contractor and by state are given in Table VI.1, the percent distribution of these is shown in Table VI.2, and the ranks among the states of the prime contract awards are illustrated in Figure VI.1. The data in these exhibits is not new, and they seem to indicate that the economic benefits of the Space Program are very heavily concentrated in four or five states and that the other 45 or so states gain little from NASA procurement spending. Figure VI.1 indicates that five states--California, Texas, Florida, Maryland, and Alabama--receive 70 percent of the NASA procurement spending, and that the remainder is distributed in relatively insignificant amounts to all the other states. This is the conventional wisdom: the economic benefits of expenditures for the U.S. Space Program flow primarily to only a few regions of the nation and most states gain little from this spending.

However, this impression is wrong. As we demonstrate below, the economic benefits of the Space Program are widely distributed throughout the nation, and among of the biggest state "winners" are many that few analysts perceive as being closely tied to the Program.

Table VI.3 shows the (direct plus indirect) economic and employment benefits of the 1987 NASA procurement budget to every state. This table clearly demonstrates that in terms of industry sales and jobs every state benefits substantially from the U.S. Space Program: cutbacks in the Program would harm businesses and cause unemployment within every state, and expansions in the Program would benefit every state. These data are extremely important, for they refute the widespread notion that the NASA budget benefits four or five states at the expense of the rest of the nation.

However, even these data are aggregate and in one sense obscure relevant information, and to further assess the state-specific benefits and their distributions we have developed three additional rankings of the states.

Table VI.4 ranks the top 20 states on the basis of the total sales generated by the Space Program. Table VI.5 ranks the top 20 states on the basis of the per capita employment created by the Space Program. Table VI.6 ranks the top 20 states on the basis of the economic benefits created indirectly within each state by the Space Program.

Focussing first on VI.4, it is observed that in terms of total sales generated the prime contract states of California, Texas, Florida, Maryland, and Alabama still clearly dominate. This is to be expected, since the total economic benefits are the sum of the direct benefits and the indirect benefits. What is interesting in this table, however, is that we are beginning to see states emerging as "winners" that get very little direct NASA procurement awards. These states include New York, Pennsylvania, Illinois, Michigan, New Jersey, Colorado, and Indiana.

Table VI.5 ranks the states on the basis of the employment created (directly and indirectly) by NASA procurement, normalized by the state's labor force. This is an important evaluation criterion, for it indicates how relatively important the jobs created (listed in Table VI.3) are in relation to the number of workers in the state. Obviously, a given number of jobs created in a small state such as Wyoming or New Hampshire are much more significant to the state than the same number of jobs created in a large state such as California, Texas, or Florida. Again we observe states beginning to emerge as clear winners that few would normally associate closely with the Space Program. These include Colorado, the District of Columbia, New Mexico, Mississippi, New Jersey, Washington, Kansas, Missouri, and New Hampshire.

Tables VI.3 through VI.5 are based on the total impacts of NASA spending and, as noted, are to a large degree dominated by the five states receiving the large prime contract awards. Table VI.6 ranks the top 20 states on the basis of the indirect benefits received from the Space Program--the economic activity generated within the state by the indirect effects of NASA procurement in all the other states. This table can show if there are substantial benefits to those states that do not receive large prime contract awards from NASA, and from the information in this table it is clear that these important benefits do exist.

Once again, California and Texas dominate the ranking of winners in this table, but abstracting from this, the results become rather interesting. First of all, several of the major prime contract award states, such as Maryland, Alabama, and Utah no longer even appear. Thus, while these states benefit substantially from the direct procurement awards, they receive relatively little indirect economic stimulus from NASA-induced business in other states.

Second, other major prime contract award states, such as Florida, Louisiana, Connecticut, and Virginia, are now ranked much lower. Again, these states do not contain the types of industries that benefit from the indirect economic stimulus of the NASA expenditures.

Third, Ohio, which ranks tenth in terms of prime contract awards, now ranks third on the basis of its industrial infrastructure.

Finally, and most interesting, we find a new set of states being identified as major (indirect) benefactors of the U.S. Space Program. These include the major manufacturing states of New York, Illinois, Michigan, Pennsylvania, Indiana, Missouri, New Jersey, and Wisconsin. These states represent the manufacturing heartland of the U.S. and benefit substantially by producing the products required by the prime contractors and the subcontractors to NASA. Other states noteworthy in Table VI.6 include Georgia, Massachusetts, Washington, North Carolina, and Tennessee.

Each of these states had a 1987 total/direct multiplier well above the average of 2.1, and the multipliers for several of these states exceed 10 to 1--see Table VI.7. Thus, as shown in this table:

- For every dollar Michigan received directly in 1987 Space Program funds, it received $10 indirectly in Program-induced business.
- For every dollar Illinois received directly in 1987 Space Program funds, it received $7 indirectly in Program-induced business.
- For every dollar Oregon received directly in 1987 Space Program funds, it received $5 indirectly in Program-induced business.
- For every dollar North Carolina received directly in 1987 Space Program funds, it received $5 indirectly in Program-induced business.

The above analysis allows us to categorize the states which are directly or indirectly (or both) the major benefactors of the U.S. Space Program. These are shown in Table VI.8. Category A contains those states which receive the major NASA prime contract awards and which have been traditionally assumed to be tied closely to the Space Program. Category B identifies those states that benefit significantly on a per capita basis and/or indirectly from the Space Program and which have not traditionally been tied closely to the Program or to the NASA budget.

This study thus finds that while high prime contract award states such as California, Texas, and Florida benefit greatly from NASA procurement spending, so also do states such as Michigan, which receive only a relatively small portion of the NASA direct procurement budget. In 1987, NASA procurement spending created (directly and indirectly) $390 million in industry sales and 3,730 jobs in Michigan. Further, in this state for every direct dollar of NASA spending, an additional 11 dollars of spending were generated indirectly by the NASA procurement budget.

This at first glance may seem counterintuative, since Michigan is not generally considered to be a state that benefits greatly from the Space Program. However, Michigan does benefit very substantially from NASA spending. Its industries produce the goods and services required indirectly by the recipients of NASA procurement awards: capital goods, electronic components, transmission systems, chemical products, transportation equipment, specialized business services, etc. Further, because of the widely based, indirect nature of these economic benefits to the state, Michigan will benefit greatly from NASA procurement spending in other states on a wide variety of programs, and its benefits are not tied to a specific contract, project, or program.

VI.B Detailed Effects on Louisiana and Indiana

While the above analysis gives useful summary data for each state, it is important to be able to examine each state itself in detail. For illustrative purposes here we chose to simulate the detailed effects of NASA procurement spending on Louisiana and Indiana. Louisiana benefits significantly from NASA procurement spending (in 1987 it ranked sixth in direct procurement awards), whereas Indiana does not.

Table VI.9 summarizes the overall benefits to the two states. Table VI.10 shows the sales and employment created within each industry in Louisiana and Table VI.11 shows the distribution of the jobs created in the state among major occupational categories; Tables VI.12 and VI.13 show analogous data for Indiana.

It is seen that the U.S. Space Program creates $426 million in sales and 3,900 jobs in Louisiana and $263 million in sales and 2,700 jobs in Indiana. Several points are worth noting.

First, the industrial distribution of sales and employment is very different in the two states. Similarly, the occupational distribution of the jobs differs substantially in each state.

Second, and most noteworthy, the difference between the direct and the indirect economic stimulus received in each state from the Space Program is striking:

- In Louisiana in 1987 $244 million in sales were generated directly and $182 million were generated indirectly, yielding a multiplier of 1.75.
- in Indiana in 1987 $22 million in sales were generated directly and $242 million is generated indirectly, yielding a multiplier of 12.0.

This illustrates very well the complex and divergent impact that the Space Program has on the economies of different states.

Table VI.1

NASA 1987 Procurement Awards by Type of Contractor and by State

State	Total	Business Prime	Business Subcontract	Education Nonprofit	Federal Government
		(millions of dollars)			
Alabama	455.9	362.4	66.1	12.2	15.3
Alaska	8.8	0.1	0.1	3.4	5.2
Arizona	58.7	13.3	26.7	11.3	7.5
Arkansas	3.9	0.2	0.5	0.2	2.9
California	3,104.8	1,838.3	615.0	520.7	130.7
Colorado	250.0	91.9	131.3	14.0	12.8
Connecticut	199.0	160.1	34.1	0.9	3.8
Delaware	8.0	2.0	4.3	0.5	1.3
Dist. Columbia	71.0	29.6	0.8	20.4	20.1
Florida	747.2	270.2	430.7	4.6	41.7
Georgia	53.6	23.7	9.2	3.9	16.8
Hawaii	21.3	0.2	2.1	5.4	13.6
Idaho	2.2	0.0	0.2	0.3	1.7
Illinois	44.1	6.4	16.2	10.2	11.2
Indiana	15.6	6.9	1.6	3.2	3.9
Iowa	11.5	0.1	3.6	7.0	0.7
Kansas	16.9	6.6	2.2	1.6	6.5
Kentucky	9.6	0.1	0.6	0.7	8.2
Louisiana	239.1	212.5	18.5	1.2	6.9
Maine	3.8	0.4	0.6	0.3	2.5
Maryland	664.2	578.4	31.6	33.9	20.3
Massachusetts	106.3	20.3	35.3	43.9	6.7
Michigan	23.0	6.2	2.9	10.3	3.7
Minnesota	24.8	12.9	8.5	2.0	1.3
Mississippi	72.0	54.9	9.8	1.5	5.8
Missouri	27.3	6.1	13.2	2.8	5.3
Montana	1.3	0.0	0.0	0.2	1.1
Nebraska	5.3	0.1	0.6	0.7	3.9
Nevada	3.7	0.3	0.6	0.3	2.5
New Hampshire	15.0	3.8	4.3	5.7	1.2

Table VI.1 (continued)

NASA 1987 Procurement Awards by Type of Contractor
and by State

State	Total	Business Prime	Business Subcontract	Education Nonprofit	Federal Government
		(millions of dollars)			
New Jersey	172.9	109.0	54.2	3.7	6.0
New Mexico	64.9	46.8	4.1	4.7	9.3
New York	117.1	50.6	37.9	19.2	9.3
North Carolina	30.4	0.9	1.9	6.8	20.6
North Dakota	2.8	0.1	0.0	0.1	2.6
Ohio	178.4	114.0	24.6	16.9	22.9
Oklahoma	14.4	0.0	3.6	3.2	7.7
Oregon	7.8	1.6	3.1	1.9	1.2
Pennsylvania	125.6	103.8	8.3	6.8	6.7
Rhode Island	5.4	0.8	0.8	1.8	2.0
South Carolina	16.0	0.6	0.3	0.5	14.5
South Dakota	5.1	0.1	2.9	0.4	1.7
Tennessee	22.2	13.4	0.3	3.0	5.5
Texas	829.0	644.9	91.1	39.5	53.4
Utah	302.9	282.3	16.6	1.9	2.2
Vermont	1.8	0.7	0.7	0.1	0.2
Virginia	316.0	207.9	38.9	21.7	47.5
Washington	67.9	26.7	23.7	4.6	12.9
West Virginia	1.4	0.6	0.1	0.2	0.5
Wisconsin	24.3	12.8	1.4	7.9	2.2
Wyoming	1.6	0.0	0.1	0.5	1.0
Total	8,575.5	5,325.6	1,786.0	869.0	594.9

Source: NASA FY1987 Procurement and Budget documents; and MISI; 1986.

Table VI.2

NASA 1987 Procurement Awards by Type of Contractor and by State (Percent Distribution)

State	Total	Business Prime	Business Subcontract	Education Nonprofit	Federal Government
		(percent of US total)			
Alabama	5.3	6.8	3.7	1.4	2.6
Alaska	0.1	0.0	0.0	0.4	0.9
Arizona	0.7	0.2	1.5	1.3	1.3
Arkansas	0.0	0.0	0.0	0.0	0.5
California	36.2	34.5	34.4	59.9	22.0
Colorado	2.9	1.7	7.4	1.6	2.1
Connecticut	2.3	3.0	1.9	0.1	0.6
Delaware	0.1	0.0	0.2	0.1	0.2
Dist. Columbia	0.8	0.6	0.0	2.4	3.4
Florida	8.7	5.1	24.1	0.5	7.0
Georgia	0.6	0.4	0.5	0.4	2.8
Hawaii	0.2	0.0	0.1	0.6	2.3
Idaho	0.0	0.0	0.0	0.0	0.3
Illinois	0.5	0.1	0.9	1.2	1.9
Indiana	0.2	0.1	0.1	0.4	0.7
Iowa	0.1	0.0	0.2	0.8	0.1
Kansas	0.2	0.1	0.1	0.2	1.1
Kentucky	0.1	0.0	0.0	0.1	1.4
Louisiana	2.8	4.0	1.0	0.1	1.2
Maine	0.0	0.0	0.0	0.0	0.4
Maryland	7.7	10.9	1.8	3.9	3.4
Massachusetts	1.2	0.4	2.0	5.1	1.1
Michigan	0.3	0.1	0.2	1.2	0.6
Minnesota	0.3	0.2	0.5	0.2	0.2
Mississippi	0.8	1.0	0.5	0.2	1.0
Missouri	0.3	0.1	0.7	0.3	0.9
Montana	0.0	0.0	0.0	0.0	0.2
Nebraska	0.1	0.0	0.0	0.1	0.7
Nevada	0.0	0.0	0.0	0.0	0.4
New Hampshire	0.2	0.1	0.2	0.7	0.2

Table VI.2 (continued)

NASA 1987 Procurement Awards by Type of Contractor and by State (Percent Distribution)

State	Total	Business Prime	Business Subcontract	Education Nonprofit	Federal Government
		(percent of US total)			
New Jersey	2.0	2.0	3.0	0.4	1.0
New Mexico	0.8	0.9	0.2	0.5	1.6
New York	1.4	1.0	2.1	2.2	1.6
North Carolina	0.4	0.0	0.1	0.8	3.5
North Dakota	0.0	0.0	0.0	0.0	0.4
Ohio	2.1	2.1	1.4	1.9	3.9
Oklahoma	0.2	0.0	0.2	0.4	1.3
Oregon	0.1	0.0	0.2	0.2	0.2
Pennsylvania	1.5	1.9	0.5	0.8	1.1
Rhode Island	0.1	0.0	0.0	0.2	0.3
South Carolina	0.2	0.0	0.0	0.1	2.4
South Dakota	0.1	0.0	0.2	0.0	0.3
Tennessee	0.3	0.3	0.0	0.3	0.9
Texas	9.7	12.1	5.1	4.5	9.0
Utah	3.5	5.3	0.9	0.2	0.4
Vermont	0.0	0.0	0.0	0.0	0.0
Virginia	3.7	3.9	2.2	2.5	8.0
Washington	0.8	0.5	1.3	0.5	2.2
West Virginia	0.0	0.0	0.0	0.0	0.1
Wisconsin	0.3	0.2	0.1	0.9	0.4
Wyoming	0.0	0.0	0.0	0.1	0.2
Total	100	100	100	100	100

Source: Management Information Services, Inc.; 1988.

Table VI.3

1987 Sales and Jobs Created in Each State by the U.S. Space Program

State	Sales		Employment	
	(millions)	(% of US)	(number)	(% of US)
Alabama	$633.9	3.6	7,457	3.6
Alaska	30.2	0.2	180	0.1
Arizona	176.1	1.0	2,111	1.0
Arkansas	68.4	0.4	729	0.3
California	5,219.5	29.3	63,612	30.4
Colorado	379.5	2.1	4,876	2.3
Connecticut	457.4	2.6	5,452	2.6
Delaware	24.6	0.1	249	0.1
Dist. Columbia	57.5	0.3	898	0.4
Florida	996.7	5.6	13,462	6.4
Georgia	228.2	1.3	2,743	1.3
Hawaii	17.9	0.1	257	0.1
Idaho	16.6	0.1	204	0.1
Illinois	420.5	2.4	4,801	2.3
Indiana	263.1	1.5	2,695	1.3
Iowa	72.5	0.4	903	0.4
Kansas	132.6	0.7	1,383	0.7
Kentucky	110.5	0.6	1,165	0.6
Louisiana	426.4	2.4	3,929	1.9
Maine	27.4	0.2	323	0.2
Maryland	756.5	4.3	10,342	5.0
Massachusetts	290.4	1.6	3,719	1.8
Michigan	388.9	2.2	3,727	1.8
Minnesota	126.8	0.7	1,550	0.7
Mississippi	178.7	1.0	1,858	0.9
Missouri	260.5	1.5	2,829	1.4
Montana	15.1	0.1	151	0.1
Nebraska	36.6	0.2	483	0.2
Nevada	24.3	0.1	349	0.2
New Hampshire	44.6	0.3	553	0.3

Table VI.3 (continued)

1987 Sales and Jobs Created in Each State by the U.S. Space Program

State	Sales (millions)	Sales (% of US)	Employment (number)	Employment (% of US)
New Jersey	385.5	2.2	4,810	2.3
New Mexico	108.1	0.6	1,090	0.5
New York	543.0	3.1	6,728	3.2
North Carolina	174.6	1.0	2,096	1.0
North Dakota	14.4	0.1	152	0.1
Ohio	707.7	4.0	7,264	3.5
Oklahoma	127.2	0.7	1,100	0.5
Oregon	51.0	0.3	614	0.3
Pennsylvania	460.3	2.6	5,111	2.4
Rhode Island	24.4	0.1	298	0.1
South Carolina	82.4	0.5	975	0.5
South Dakota	14.3	0.1	194	0.1
Tennessee	158.9	0.9	1,903	0.9
Texas	1,653.8	9.3	17,094	8.2
Utah	455.9	2.6	5,330	2.6
Vermont	16.0	0.1	195	0.1
Virginia	481.3	2.7	5,962	2.9
Washington	235.9	1.3	2,669	1.3
West Virginia	48.8	0.3	428	0.2
Wisconsin	149.4	0.8	1,736	0.8
Wyoming	23.9	0.1	175	0.1
Total	$17,798.8	-	208,914	-

Source: Management Information Services, Inc.; 1988.

Table VI.4

Ranking of the Top 20 States on the Basis of Total Industry Sales Generated by the U.S. Space Program

Rank	
1.	California
2.	Texas
3.	Florida
4.	Maryland
5.	Ohio
6.	Alabama
7.	New York
8.	Virginia
9.	Pennsylvania
10.	Connecticut
11.	Utah
12.	Louisiana
13.	Illinois
14.	Michigan
15.	New Jersey
16.	Colorado
17.	Massachusetts
18.	Indiana
19.	Missouri
20.	Washington

Source: Management Information Services, Inc., 1988

Table VI.5

Ranking of the Top 20 States on the Basis of Jobs Created Per Capita by the U.S. Space Program

Rank	
1.	Utah
2.	California
3.	Alabama
4.	Connecticut
5.	Colorado
6.	District of Columbia
7.	Florida
8.	Virginia
9.	Texas
10.	Louisiana
11.	New Mexico
12.	Mississippi
13.	Ohio
14.	Arizona
15.	New Jersey
16.	Massachusetts
17.	Washington
18.	Kansas
19.	Missouri
20.	New Hampshire

Source: Management Information Services, Inc., 1988

Table VI.6

Ranking of the Top 20 States on the Basis of Industry Sales Generated Indirectly in the State by the U.S. Space Program

Rank	
1.	California
2.	Texas
3.	Ohio
4.	New York
5.	Illinois
6.	Michigan
7.	Pensylvania
8.	Indiana
9.	Missouri
10.	Florida
11.	New Jersey
12.	Louisiana
13.	Connecticut
14.	Georgia
15.	Massachusetts
16.	Washington
17.	North Carolina
18.	Virginai
19.	Tennessee
20.	Wisconsin

Source: Management Information Services, Inc., 1988

Table VI.7

Economic Multipliers of the U.S. Space Program for Selected States

	Multiplier[a]
Indiana	12.0 to 1
Michigan	10.9 to 1
Missouri	8.5 to 1
Illinois	8.1 to 1
Kansas	7.2 to 1
Tennessee	7.0 to 1
Oregon	6.3 to 1
North Carolina	5.8 to 1
Wisconsin	5.5 to 1
New York	4.6 to 1
Ohio	4.0 to 1
Mississippi	2.5 to 1
New Jersey	2.2 to 1
Texas	2.0 to 1
California	1.7 to 1
Alabama	1.4 to 1
Florida	1.3 to 1

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[a] Ratio of total (direct plus indirect) economic benefits to direct economic benefits.

Source: Management Information Services, Inc., 1988.

Table VI.8

Categorization of the States Benefiting Most From the U.S. Space Program

Category A

Major Prime Contract Award States

California
Texas
Florida
Maryland
Alabama
Louisiana
Utah
Virginia
Connecticut
Ohio

Category B

States Benefiting Indirectly From the U.S. Space Program

Colorado
New Jersey
New York
Arizona
Mississippi
Kansas
Indiana
Illinois
Michigan
Tennessee
Washington
Massachusetts
Missouri
Wisconsin
New Hampshire
New Mexico
Georgia
District of Columbia
North Carolina

Source: Management Information Services, Inc., 1988

Table VI.9
Summary of the Benefits to Louisiana and Indiana of the U.S. Space Program in 1987

Direct Sales	
Louisiana (millions)	$244
Indiana (millions)	$22
Total Sales Generated	
Louisiana (millions)	$426
Indiana (millions)	$264
Indirect Economic Multiplier	
Louisiana	1.75
Indiana	12.0
Total Jobs Created	
Louisiana	3,929
Indiana	2,695
Total Profits Generated (millions)	
Louisiana (millions)	$69.8
Indiana (millions)	$40.7

Source: Management Information Services, Inc., 1988

Table VI.10

Sales and Jobs by Industry Created in Louisiana by the U.S. Space Program in 1987

Industry Title	Sales (millions)	Jobs (number)
Livestock & livestock products	$0.6	7
Other agricultural products	1.7	40
Forestry & fishery products	0.2	2
Agricultural, forestry & fishery services	0.2	10
Iron & ferroalloy ores mining	0.1	1
Nonferrous metal ores mining	0.3	3
Coal mining	0.1	0
Crude petroleum & natural gas	93.1	213
Stone & clay mining & quarrying	0.7	9
Chemical & fertilizer mineral mining	0.4	3
New construction	7.1	102
Maintenance & repair construction	15.0	197
Ordnance & accessories	28.0	266
Food & kindred products	1.8	10
Tobacco manufactures	0.0	0
Broad & narrow fabrics, yarn & thread mills	0.5	6
Miscellaneous textile goods & floor coverings	0.1	1
Apparel	0.5	12
Miscellaneous fabricated textile products	0.2	4
Lumber & wood products, exc. containers	2.7	32
Wood containers	0.1	2
Household furniture	0.0	1
Other furniture & fixtures	0.0	1
Paper & allied products	3.5	22
Paperboard containers & boxes	1.3	13
Printing & publishing	2.7	41
Chemicals & selected chemical products	10.3	56
Plastics & synthetic materials	3.3	17
Drugs, cleaning & toilet preparations	1.3	8
Paints & allied products	1.0	7
Petroleum refining & related industries	44.8	46
Rubber & miscellaneous plastics products	1.5	18
Leather tanning & finishing	0.0	0
Footwear & other leather products	0.0	0
Glass & glass products	0.5	6
Stone & clay products	1.6	19
Primary iron & steel manufacturing	3.1	22
Primary nonferrous metals manufacturing	3.6	26
Metal containers	0.3	1
Heating, fabricated metal products	2.5	37
Screw machine products & stampings	1.9	23
Other fabricated metal products	3.0	38

Table VI.10 (continued)

Sales and Jobs by Industry Created in Louisiana by the U.S. Space Program in 1987

Industry Title	Sales (millions)	Jobs (number)
Engines & turbines	1.0	9
Farm & garden machinery	0.1	1
Construction & mining machinery	0.3	2
Materials handling machinery	0.2	3
Metalworking machinery	0.7	10
Special industry machinery	0.1	2
General industrial machinery	1.0	11
Miscellaneous machinery, except electrical	1.1	21
Office, computing, & accounting machines	1.3	17
Service industry machines	0.2	2
Electrical transmission equipment	1.3	20
Household appliances	0.1	1
Electric lighting & wiring equipment	0.4	5
Radio, TV & communication equipment	8.9	103
Electronic components	4.2	67
Miscellaneous electrical machinery	0.3	4
Motor vehicles & equipment	2.8	14
Aircraft & parts	49.6	485
Other transportation equipment	6.6	89
Professional & scientific supplies	0.1	3
Optical & photographic equipment	0.1	2
Miscellaneous manufacturing	0.2	4
Transportation & warehousing	24.6	344
Communications, except radio & TV	4.2	45
Radio & TV broadcasting	1.0	14
Electric, gas, & sanitary services	21.2	73
Wholesale & retail trade	13.0	404
Finance & insurance	4.5	58
Real estate & rental	6.5	16
Hotels & personal services	3.0	127
Business services	17.6	364
Eating & drinking places	3.6	121
Automobile repair & service	1.2	15
Amusements	0.7	16
Health & educational & nonprofit	1.3	40
Federal government enterprises	1.5	43
State & local government enterprises	2.1	54
Total	$426.4	3,929

Source: Management Information Services, Inc.; 1988.

Table VI.11

Jobs by Occupational Group Created in Louisiana by the U.S. Space Program in 1987

Major Occupational Category	Jobs
Managerial and Professional Specialty Occupations	
Executive, administrative, and managerial occupations	453
Professional specialty occupations	502
Technical, Sales, and Administrative Support Occupations	
Technicians and related support occupations	148
Sales occupations	317
Administrative support occupations, including clerical	594
Service Occupations	
Protective service occupations	33
Service occupations, except protective	251
Farming, Forestry, and Fishing Occupations	
Farm operators and managers	23
Other agricultural and related occupations	30
Forestry and logging occupations	6
Fishers, hunters, and trappers	1
Precision Production, Craft, and Repair Occupations	
Mechanics and repairers	203
Construction trades	221
Extractive occupations	57
Precision production occupations	272
Operators, Fabricators, and Laborers	
Machine operators, assemblers, and inspectors	391
Transportation and material moving occupations	265
Handlers, equipment cleaners, helpers, and laborers	160
Total	3,929

Source: Management Information Services, Inc.; 1988.

Table VI.12

Sales and Jobs by Industry Created in Indiana by the U.S. Space Program in 1987

Industry Title	Sales (millions)	Jobs (number)
Livestock & livestock products	$0.5	6
Other agricultural products	1.4	35
Forestry & fishery products	0.1	1
Agricultural, forestry & fishery services	0.1	3
Iron & ferroalloy ores mining	0.0	0
Nonferrous metal ores mining	0.0	0
Coal mining	2.0	15
Crude petroleum & natural gas	0.3	1
Stone & clay mining & quarrying	0.2	3
Chemical & fertilizer mineral mining	0.1	1
New construction	2.3	34
Maintenance & repair construction	4.8	65
Ordnance & accessories	29.5	287
Food & kindred products	1.2	7
Tobacco manufactures	0.0	0
Broad & narrow fabrics, yarn & thread mills	0.1	1
Miscellaneous textile goods & floor coverings	0.0	0
Apparel	0.3	6
Miscellaneous fabricated textile products	0.1	2
Lumber & wood products, exc. containers	1.6	20
Wood containers	0.1	1
Household furniture	0.3	5
Other furniture & fixtures	0.2	3
Paper & allied products	1.0	7
Paperboard containers & boxes	0.4	4
Printing & publishing	2.0	32
Chemicals & selected chemical products	5.1	29
Plastics & synthetic materials	1.6	9
Drugs, cleaning & toilet preparations	0.6	4
Paints & allied proucts	0.5	3
Petroleum refining & related industries	3.6	4
Rubber & miscellaneous plastics products	5.8	73
Leather tanning & finishing	0.0	0
Footwear & other leather products	0.0	1
Glass & glass products	0.4	5
Stone & clay products	1.4	17
Primary iron & steel manufacturing	22.8	166
Primary nonferrous metals manufacturing	25.9	192
Metal containers	0.3	2
Heating, fabricated metal products	3.0	46
Screw machine products & stampings	2.4	29
Other fabricated metal products	3.7	47

Table VI.12 (continued)

Sales and Jobs by Industry Created in Indiana
by the U.S. Space Program in 1987

Industry Title	Sales (millions)	Jobs (number)
Engines & turbines	1.8	16
Farm & garden machinery	0.1	1
Construction & mining machinery	0.5	4
Materials handling machinery	0.3	5
Metalworking machinery	1.2	19
Special industry machinery	0.2	3
General industrial machinery	1.8	21
Miscellaneous machinery, except electrical	2.1	38
Office, computing, & accounting machines	3.2	41
Service industry machines	0.5	4
Electrical transmission equipment	3.0	48
Household appliances	0.3	3
Electric lighting & wiring equipment	0.9	11
Radio, TV & communication equipment	21.4	253
Electronic components	10.0	164
Miscellaneous electrical machinery	0.7	9
Motor vehicles & equipment	9.4	50
Aircraft & parts	33.0	329
Other transportation equipment	4.4	61
Professional & scientific supplies	1.2	22
Optical & photographic equipment	1.2	13
Miscellaneous manufacturing	0.5	7
Transportation & warehousing	10.5	152
Communications, except radio & TV	2.1	23
Radio & TV broadcasting	0.5	7
Electric, gas, & sanitary services	6.7	24
Wholesale & retail trade	5.2	165
Finance & insurance	2.0	27
Real estate & rental	2.5	6
Hotels & personal services	1.1	50
Business services	4.6	99
Eating & drinking places	1.5	50
Automobile repair & service	0.6	8
Amusements	0.2	5
Health & educational & nonprofit	0.7	22
Federal government enterprises	0.5	13
State & local government enterprises	0.9	25
Total	$263.1	2,965

Source: Management Information Services, Inc.; 1988.

Table VI.13

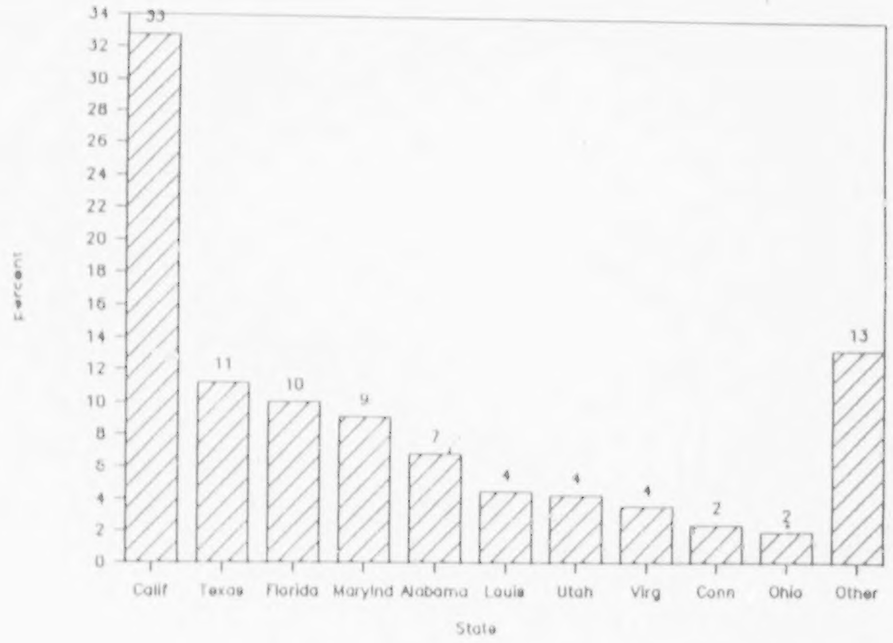
Jobs by Occupational Group Created in Indiana by the U.S. Space Program in 1987

Major Occupational Category	Jobs
Managerial and Professional Specialty Occupations	
Executive, administrative, and managerial occupations	299
Professional specialty occupations	318
Technical, Sales, and Administrative Support Occupations	
Technicians and related support occupations	126
Sales occupations	140
Administrative support occupations, including clerical	367
Service Occupations	
Protective service occupations	18
Service occupations, except protective	102
Farming, Forestry, and Fishing Occupations	
Farm operators and managers	19
Other agricultural and related occupations	19
Forestry and logging occupations	3
Fishers, hunters, and trappers	0
Precision Production, Craft, and Repair Occupations	
Mechanics and repairers	160
Construction trades	103
Extractive occupations	5
Precision production occupations	281
Operators, Fabricators, and Laborers	
Machine operators, assemblers, and inspectors	502
Transportation and material moving occupations	129
Handlers, equipment cleaners, helpers, and laborers	103
Total	2,695

Source: Management Information Services, Inc.; 1988.

Figure VI.1

NASA Prime Contract Awards, 1987, by State as a Percent of the U.S. Total



Source: Management Information Services, Inc., 1988

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APPENDIX 10

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Edward Donley
Chairman, Executive Committee

AIR PRODUCTS

May 10, 1989

Ms. Susan Dumay
Subcommittee on Space Science
& Applications
House Committee on Science
Space, and Technology
2321 Rayburn House Office Building
Washington, D.C. 20515

Dear Ms. Dumay:

On Tuesday, April 11, 1989, I testified before the Subcommittee on Space Science & Applications in connection with the Subcommittee hearing on the FY-'90 NASA Authorizations for the Office of Commercial Programs. A copy of the trancript is enclosed.

I request that the following information be included in the hearing record:

page [illegible], line [illegible] - Add "fluids" after the word cryogenic

I understand that this letter may be inserted in the transcript in the form of an appendix and referred to by footnote in the main text.

Sincerely,

Ed Donley

mlh/2125f

Enclosure

APPENDIX 11

Question No. 1. Nearly 25% of your budget request ($1.06 million) will support commercial launch operations and ranges.

--Do you intend to support commercial activities of existing ranges, or does this include planned commercial ranges/sites? Please elaborate.

--What kind of activities will be supported?

The OCST's research supports the regulation of commercial activities both at the existing ranges and at future commercial launch sites. Research OCST performs permits it to regulate activities today, as well as stay ahead of the commercial launch industry tomorrow, regardless of the site from which industry launches. Without these funds, the OCST will not be able to meet the needs presented by a dynamic industry. The long lead times in research make it exceedingly important that the OCST addresses issues well in advance of the need for specific information. For example, the hazards and risk research initiated by OCST two to three years ago gave OCST the capability to respond to the insurance requirements imposed by Congress in the Commercial Space Launch Act amendments. Had this research not been conducted in advance, OCST would not have had the capability to set insurance requirements today.

Regulating a commercial space transportation industry is very different from launching rockets or operating launch ranges and requires a different kind of research than that conducted by NASA or the Air Force in the past. We are conducting research in order to form the analytical underpinning for an efficient regulatory program. The emergence of a dynamic and changing commercial launch industry has an effect on safety regardless of whether the launch activity takes place from government operated launch facilities or from a commercial launch facility.

For example, the following activities have effects on safety operations at government facilities and are thus of concern to the regulatory and licensing activities of OCST:

- Totally new launch vehicles such as the Pegasus which launches from an aircraft present a whole new concept for the "launch range" and range safety systems.
- Orbiting payload systems capable of being returned to earth on command require establishment of new safety standards for guidance (personnel and equipment), flight termination, tracking and other safety policies for the recovery range.
- American Rocket Company is developing a new hybrid fueled vehicle different from those presently being used.

Over the longer term, the research provides the database and information to license new commercial launch site facilities and activities.

- Both the States of Florida and Hawaii have initiated master plan development in addition to Environmental Impact Statements preparation for commercial spaceports.
- U.S. commercial launches from the Australian commercial range under development would also require licensing of a unique kind.

These initiatives on the part of the commercial industry are already generating requests for regulatory guidance. During FY90, as these move closer to operational status, inquiries will increase substantially, since this information becomes critical to their design decisions. In light of international competition issues and rapidly changing technology/concepts, extreme care must be taken to maintain a maximum amount of flexibility.

Question No. 2. Your budget places great emphasis on safety research in support of commercial launch and range operations.
--When do you anticipate the major safety studies will be completed, and recommendations formulated?
--What is your anticipated schedule for implementing findings, new procedures, etc. at the ranges?

These on-going research programs are not necessarily formal studies as much as they are research projects which gradually produce data and information which supports the office's regulatory and licensing decisions. The results are incorporated immediately into the regulatory data base and used as appropriate. In some instances, reports are generated, but more often than not the product of the research surfaces in OCST regulatory and licensing actions. The benefits of research also appear when OCST is confronted with new technologies, and because of the research, is able to address the public safety issues immediately, without long delays to the applicant.

As an example of how research translates into an OCST product, the office has conducted research for several years in the areas of launch hazards, risks, damage consequences, and environmental effects. Research in this area is still continuing. Some of the results of this research has been encapsulated in the Hazard Analysis Report. Other information is used in licensing decisions, setting insurance levels, and evaluating commercial proposals.

STAR DATABASE

Q 3. Your testimony indicates you are developing a Space Transportation Analysis and Research (STAR) database, to compile evaluative capabilities covering national and foreign space launch systems, markets, and regulatory environments.

-- Will it be available for access by outside (non-DOT) user?

-- How will it be accessed? Electronically? In-house library? Where?

-- Are foreign launch providers and governments providing information? How is such information sharing approached?
[The information follows:]

OCST's primary purpose in developing the Space Transportation Analysis and Research (STAR) database is to support our own internal policy, planning, promotion, and regulatory activities. The database will be accessed on computers located within the OCST office space. We have no current plans to share on-line access to outside users. This policy is driven by the presence of sensitive data within the database, but more importantly by our concern that unrestricted access would unfairly compete with commercial aerospace data services. We plan to make some data available to non-DOT users, but on a controlled basis.

We are obtaining information on foreign launch providers and governments from their publications, industry sources, and the trade press. Proprietary foreign data to be provided under the terms of existing or future agreements with foreign organizations or governments will be carefully segregated from the STAR system. Domestic proprietary data will also be protected.

Question No. 4. Please describe your interaction with the Department of Defense and NASA, who own the ranges, concerning implementation of new safety procedures for commercial launch operations.
--Who is your point of contact within the DOD?
--Who is your point of contact within NASA?

The OCST coordinates the review of each mission with the Department of Defense and NASA in order to ensure protection of the interests of the United States. The OCST does not impose safety procedures on the ranges. There is a free exchange of information with the ranges concerning the establishment of insurance requirements.

OCST works in close coordination with DOD and NASA concerning commercial operations at the national ranges. On virtually any issue concerning government ranges, including licensing or inspecting commercial activities, or setting insurance requirements, OCST relies to some degree on DOD or NASA support. For example, prior to the Space Services Incorporated launch, OCST signed a memorandum of agreement with White Sands Missile Range outlining each agencies responsibilities.

The formal point of contact with NASA is the Office of Space Flight and for DOD is the Office for Space Policy. Of course, OCST has direct contact with each of the range facilities.

Question No. 5. What steps are you taking to anticipate a launch accident? Are you developing procedures that would facilitate the government's efforts to respond to a launch accident?
--Are you developing a plan?
--When will it be available?

OCST has developed an accident investigation plan establishing the procedures for conducting an investigation and implementing corrective actions. This plan was in place prior to the Space Services Incorporated launch on March 29. The plan will be revised because the National Transportation Safety Board has agreed to be the lead investigation agency in any accident affecting public safety involving commercial launch activities.

COMMERCIAL LAUNCH DEMAND PROJECTIONS

Q 6. In your supporting data provided to the committee, you identify efforts to evaluate demand structures and markets for space launch services, and trends in:

- -- materials processing;
- -- microgravity pharmaceutical production;
- -- satellite telecommunications;
- -- remote sensing
- -- Space Station construction and operations.

Can you describe your findings and projections in these areas to date?

[The information follows:]

OCST is actively attempting to develop structured, quantitative market forecasts of commercial launch services. As is characteristic of other forecasting efforts inside and outside the government, however, we are currently able to forecast only the relatively mature commercial space activities (i.e., telecommunications and, to a lesser extent, earth remote sensing) with any confidence.

The current outlook for communications satellites available to the world commercial launch industry is approximately 12 to 15 commercial satellites per year for the next decade. As some of these satellites will be carried aloft in pairs on dual launches, this is equivalent to fewer than 15 commercial launches.

Earth remote sensing, which includes meteorological and Earth observational systems, has not yet proven to be fully commercially viable, for a variety of reasons. Thus, the methodology for forecasting entails looking at the long term plans of various national governments. In general, an average of five satellites per year of this type can be expected for the 1990's, evenly split between the two types.

Materials processing and pharmaceutical production in microgravity/vacuum environments are two promising areas for future commercial space activity. Unfortunately, future activities in these areas are extremely difficult to forecast, in part because the government acts more as a facilitator to the scientific community and to private industry than as an initiator of these activities. The development of less expensive launch services will be critical for expanded commercial initiatives. OCST anticipates that below a certain threshold launch price, microgravity payloads will surge. However, what this threshold price may be, and when it will be reached, are unknown. However, OCST expects that microgravity payloads will become substantially more important to the commercial launch industry within the next 10 years, and will not necessarily be dependent on the Space Station. In this view, OCST is somewhat more optimistic than the industry at large.

Commercial launch support for Space Station construction and operations is also a promising area. However, the size of this market is uncertain at this time.

Finally, in addition to the payloads described above, the U.S. commercial launch industry will benefit from a variety of miscellaneous government civil and military payloads such as the

LACE/RME payload recently booked on a commercial Delta vehicle for a December 1989 launch. The number of future payload opportunities of this sort, particularly from classified programs such as SDI, is difficult to project but will be significant.

Question No. 7. How many launch license applications are currently pending before your office?

--How many commercial launches do you anticipate being conducted this year.

--How many launches do you anticipate next year?

The following companies currently have launch license applications pending:

Company	Payload	Launch Date
AMROC	SET-1	07/89
McDonnell Douglas	BSB-R1	08/89
McDonnell Douglas	PAPAPA B2-R	03/90

A total of 6-8 launches is expected during fiscal year 1989 and up to 20 launches next fiscal year. Following is the latest commarcial launch manifest. Additional launches are expected.

U.S. COMMERCIAL LAUNCH MANIFEST
(As of May 1989)

COMPANY	PAYLOAD	CUSTOMER LAUNCH DATE
Space Services, Inc.	Microgravity Research	3/89
McDonnell Douglas	INSAT 1-D (Indian)	5/89
AMROC	Microgravity Research	7/89
Martin Marietta[1]	JCSAT (Japanese) Skynet (British)	7/89
McDonnell Douglas	BSBR1 (British)	8/89
Martin Marietta	INTELSAT VI (Intern'l Consortium)	10/89
McDonnell Douglas	INMARSAT-2 Flt#1 (Intern'l Consortium)	12/89
McDonnell Douglas	LACE/RME[2] (U.S. Govt.)	12/89
Conatec	Microgravity Research	12/89
Conatec	Microgravity Research	12/89
Martin Marietta	INTELSAT VI (Intern'l Consortium)	2/90
General Dynamics	EUTELSAT (European)	3/90
McDonnell Douglas	PALAPA B2-R (Indonesian)	3/90
McDonnell Douglas	INMARSAT-2 Flt#2 (Intern'l Consortium)	5/90

McDonnell Douglas	BSBR2 (British)	6/90
General Dynamics	GOES I (U.S. Govt.)	7/90
General Dynamics	CRRES (U.S. Govt.)	9/90
McDonnell Douglas	NATO IVA (Intern'l Consortium)	12/90
McDonnell Douglas	AURORA II (U.S. company)	4/91
General Dynamics	GOES J (U.S. Govt.)	11/91
General Dynamics	GOES K (U.S. Govt.)	5/92
Martin Marietta	Hughes HS601	/92
Martin Marietta	Hughes HS601	/93

Footnotes:

1. The payloads will share the same vehicle.
2. Low Atmospheric Composition Explorer/Remote Mirror Experiment

ABILITY TO MEET LAUNCH SCHEDULES

Q 8. The Air Force is predicting they may not be able to meet the 1989 launch schedule due to hardware problems, manpower shortages, and environmental requirements. The commander of the Eastern Space and Missile Center has predicted only 70 percent, at best, of planned missions will get off the ground (Aviation Week).

-- If scheduling conflicts do occur, how will the commercial community be affected at the ranges?

[The information follows:]

Twenty-five military and commercial launches are scheduled at the Eastern Space and Missile Center (ESMC) for 1989, including 7 Shuttle launches, which have already experienced some widely-publicized schedule slippages. ESMC is gearing up to the new demand for expendable launch vehicles, and is also incorporating the new commercial sector into its operations.

The range is particularly vulnerable to slippages caused by vehicles delayed on the pad, largely caused by either vehicle or payload technical problems. Because the range is being pushed to capacity in so far as pad availability, there are not many alternatives to slippage if a pad is taken up by an inoperative vehicle.

The Commander of ESMC stated that it would take "luck" to meet the launch schedule and that "If we can get 70 percent up, we will have earned our pay." However, other Air Force personnel do not seem to share this assessment of the situation, at least not in so far as the commercial missions are concerned. Space Division's Office of Space Commercialization has indicated publicly that it is "fairly confident" that all scheduled commercial missions will get off in 1989.

OCST is currently in the final stages of a Congressionally-mandated study that is reviewing the scheduling procedures at the government ranges. The study's findings are under review, but it can be noted that the scheduling practices of the ranges are designed to cope with multiple user demands on range resources. Moreover, for a variety of policy reasons (especially Section 7 of the Amendments to the Commercial Space Launch Act) and technical reasons, it is highly unlikely that a commercial launch would be pre-empted by a military mission.

However, commercial users have access to the range on a "non-interference basis" according to the Model Agreement they sign with the range. This suggests that in conflict situations, commercial users will not always get equal access to range resources, and has implications for the commercial environment at the ranges.

SCHEDULING STUDY

Q 9. Your office has been charged with studying "ways and means of scheduling government and commercial launches on government launch ranges" with the objectives of understanding scheduling problems and formulating a commercially reasonable approach to addressing them.

-- What is the status of this study?

-- Are you working with Industry? NASA? Air Force?

-- Are you still planning to submit the report in May?

[The information follows:]

The draft study, including appendices, is complete, and is being circulated for review within the Office of the Secretary at DOT, as well as NASA and the Air Force. All parties with an interest in scheduling issues were consulted in preparing the study report. Industry sources included large and small domestic commercial launch companies, as well as satellite payload customers. Extensive interviews were conducted with the Air Force, which cooperated fully and submitted extensive supporting documentation. NASA is submitting a written response to questions posed by OCST.

OCST is still planning to submit the report in May. In part, the ability to meet this deadline is contingent on the review process, which OCST is making every effort to expedite.

Question No. 10. Legislation enacted last year directs your office to set maximum probable loss standards for the determination of property and liability coverage in conjunction with commercial launch activities.

--You have already provided such direction for Deke Slayton's launch. The next launch (Delta) is scheduled in May.

--Do you feel that your office is positioned to provide this information to keep to the launch schedules for 1989 and 1990.

Yes, OCST is positioned to address maximum probable loss levels for activities occurring in 1989 and 1990. During the past several years, the office has considered the development of hazards, risk and loss data to be critical to its licensing and insurance setting responsibilities. Because of the long lead times needed to develop this information, OCST started its research in the hazards and risk fields two to three years ago. Because of this early effort, we were able to set maximum probable loss standards and set insurance coverage requirements prior to the launch of Starfire and the scheduled Delta launch. Although the requirements have not yet been issued, insurance requirements already have been determined for the major launch companies.

Question No. 11. How would you assess the current health of the insurance industry to respond to the launch coverage requirements?

> **--Have there been any particular problems obtaining information in order to provide guidance concerning insurance coverage for government property? Please elaborate.**

The insurance industry appears to have had no difficulties providing coverage for third party and property insurance for commercial launch activities. Space Services Incorporated was able to obtain insurance for its March 29 launch. In addition, all the major launch companies have been able to acquire property insurance at the levels set by DOT. Third party insurance requirements have not yet been issued by DOT.

One of the reasons we believe there has not been a problem is that OCST has spent considerable time interacting with the insurance and underwriting community. The Commercial Space Risk and Insurance Symposium, cosponsored by OCST, was well attended by the insurance industry and provided the industry with comprehensive data on risks. As a result, some new insurance companies have entered this market.

There have been no problems obtaining the necessary information from other Federal agencies. In fact, the agencies have been very cooperative in providing information about cost of facilities, accident histories, expected risks, etc. This cooperation and support have helped the OCST to develop one of the most comprehensive data bases in this area.

Question No. 12. Are there any areas of the recently enacted Commercial Launch Act amendments that require further clarification, or modification? If so, what are they?

The objectives of the legislation are complex. The OCST has been implementing the requirements of the amendments. Insurance requirements based on maximum probable loss and requiring interparty cross waivers have been issued to the industry. It remains to be seen what long term effects these requirements will have on the industry and U.S. competitiveness. Until further experience is gained, we see no need to propose clarifications or modifications.

GOVERNMENT PURCHASES

Q 13. How would you assess current progress toward government purchase of commercial launch vehicles?

Q 14. Does your office have underway any effort to identify commercially reasonable methods that the government might adopt as it transitions toward commercial launch services procurements?

Q 15. Has your office considered formulating a model RFP, or model contract, that the government might adopt for launch service purchases?

-- Would it be better for an agency issuing an RFP for launch services to release the RFP in draft, for industry comments? [The information follows:]

One of the fifteen points in the Commercial Space Initiative of February 11, 1988, read as follows:

> 3. Reliance on Private Launch Services: Federal agencies will procure existing and future required expendable launch services directly from the private sector to the fullest extent feasible.

Although considerable progress has been made in this area, the recent protests from the commercial sector concerning the Medium Expendable Launch Vehicle RFP issued by NASA would indicate that much remains to be done. The commercial sector is concerned that various provisions of the RFP preclude the procurement from being a truly commercial transaction, especially the provisions for government inspection, DCAA audits, and other non-commercial clauses. The Commercial Space Transportation Advisory Committee (COMSTAC) Procurement Working Group recently summarized these concerns, and drafted a set of recommendations for improving the commercial procurement environment.

OCST has been working with the Office of Federal Procurement Policy, COMSTAC, DOD, and NASA to promote further progress. In these efforts, we will consider identification and promotion of commercially reasonable methods, the formulation of a model RFP or model contract, and whether RFP's should first be released to the industry in draft.

Question No. 16. The commercial Launch Act limits DOT's authority, stating "nothing in this Act shall apply to ...any...launch or operation of a launch vehicle, ...carried out by the United States on behalf of the United States." (Section 21(c), P.L. 98-57). The legislative history further makes clear that "all government launch activities are exempt from any provisions of this bill." Further, a license is required only from persons engaged in non-government launch operations."

--Now that we are moving toward government use of commercial launch vehicles, how should licensing be approached?

--Should we be developing procedures for these hybrid launches (government payloads on commercial launch vehicles)?

The existing system is adequate to handle licensing commercial launches that involve government payloads. Ample precedent exists in nonspace fields to define how the government should handle this situation with respect to space activities. In most industries, regulation focuses on the operator, not the customer. For example, if the government charters an airplane flight, that flight is regulated by the Federal Aviation Administration, even though the customer is the U.S. government. The current commercial launch manifest identifies the following missions where the government is the launch customer, not the launch operator: LACE/RME, GOES I, GOES II, GOES J, and GOES K.

With regard to the statutory licensing requirement, the only launch activities not covered by the Act are those that are "carried out by the United States on behalf of the United States." We interpret this provision as addressing such operations as NASA's space shuttle operations or Air Force, MLV, MLV II, and Titan launches. In these instances, NASA and the Air Force are acting as the launch operator and are responsible, on behalf of the U.S. Government, for protecting all national interests associated with the conduct of space activities.

ROLE OF DOT IN THE US-CHINA LAUNCH SERVICES AGREEMENT

Q 17. The Administration has recently issued the export license for two American satellites to be launched on the Chinese Long March.

-- What will be the DOT role in overseeing this agreement?

-- Will Dot have enforcement responsibility?

-- Who will serve with DOT on the committee overseeing the agreement?

[The information follows:]

On January 26, 1989, representatives of the governments of the United States and the People's Republic of China (PRC) signed a Memorandum of Agreement Regarding International Trade in Commercial Launch Services. The Agreement requires China to price its launch services at international rates, terms, and conditions and will enable China to launch U.S.-built communications satellites. However, it limits China to the launch of not more than 9 communications satellites for international customers over the next six years (through 1994), and further requires that the 9 launches be spaced evenly over this period. The Agreement thereby limits the impact of China's competition with U.S. and European commercial launch services, but serves as a formal acknowledgment to the world market of China's role as a provider of international commercial launch services.

The Trade Policy Staff Committee (TPSC) Subcommittee on Commercial Launch Services, chaired by USTR, was the interagency group responsible for negotiating the Agreement. Pursuant to the implementation plan published in the Federal Register at the time the Agreement was signed, this Subcommittee has also been given responsibility for ensuring PRC compliance. The plan calls for establishment of a Working Group on Information, chaired by DOT and with representation from the Departments of State and Commerce, to assemble data on market developments and to make preliminary assessments concerning PRC compliance. The full Subcommittee will review these preliminary assessments. Thus, the Subcommittee, not the Working Group, is vested with ultimate authority to monitor and assess compliance.

formal agreement. We are now engaged in extensive discussions with affected U.S. industries concerning whether such a negotiation at this time would be in the interest of the U.S. Obviously we are going to continue to discuss with ESA all relevant matters of concern. The only issue is whether the U.S. now intends to proceed to conclude a formal agreement. A decision on this issue should be forthcoming shortly.

DISCUSSIONS WITH THE EUROPEAN SPACE AGENCY

Q 18. What is the status of talks with the European Space Agency concerning the development of "rules of the road" for international launch competitions?

[The information follows:]

For the past two years the U.S. government has been engaged in informal discussions with the European Space Agency (ESA) concerning the forms and levels of government supports each side furnishes its respective launch services providers. ESA has long sought to negotiate some arrangement on principles concerning the provision of such supports with the objective of establishing the basis for an international discipline in this area. ESA has become increasingly concerned about the need for such an agreement following the entrance of the Chinese into the international market.

There has been concern with placing limits on the supports European governments, through ESA, provide to Arianespace. The supports include not only direct financial support but also the marketing inducements that European governments, particularly France, have provided in support of Arianespace's marketing efforts. The extent to which an agreement with ESA could effectively discipline these practices remains, however, an open question.

Recently, ESA informed the United States Trade Representative that it did not wish to proceed with further exploratory discussions without an indication that the U.S. wants to negotiate a

INTERNATIONAL COMPETITION

Q 19. How would you currently assess the state of competition in this intensely dynamic world marketplace?
[The information follows:]

The U.S. commercial space transportation industry has obtained contracts to launch more than 20 satellites, and is aggressively pursuing more. U.S. commercial companies will launch one-third of the orbital payloads to be carried on commercial vehicles in FY 1990, up from only 25 percent in FY 1989. To meet future demand, U.S. companies continue to invest in their commercial launch programs, including investments in launch range facilities and launch vehicles. To date, this investment amounts to more than $500 million.

Europe's Arianespace has been the dominant commercial launch company. Arianespace hopes to maintain approximately half of the world commercial launch market over the next decade. To meet this objective, and to lower launch costs, it recently ordered 50 Ariane 4 launch vehicles -- an order worth almost $3 billion.

Under the recent Memorandum of Agreement between the Government of the United States of America and the Government of the People's Republic of China Regarding International Trade in Commercial Launch Services, China is limited to launches of nine communications satellites for international customers during the next six years (to be spread out evenly over this period) and is required to offer prices, terms, and conditions on a par with those in the world marketplace. If this limit is met, China would capture about 10 percent of the projected commercial launch market.

For technology transfer reasons, the Soviet Union is prohibited from launching western payloads.

SOVIET LAUNCHES

Q 20. Has the Administration considered any change to its position which prohibits the entry of the Soviet Union into the western market?
[The information follows:]

During the Senate hearings of March 15 and 16, 1989 on the nomination of Lawrence S. Eagleburger to be Deputy Secretary of State, Mr. Eagleburger was asked this question. His response for the record is as follows:

> The United States Government's long-standing policy is to deny the export to the Soviet Union of space electronics equipment and related technologies with significant military applications. This policy is stipulated in the International Traffic in Arms Regulations. Soviet officials have been informed of these prohibitions.
>
> There is broad agreement that at this time adequate measures do not exist and could not be devised to safeguard U.S. technology while a satellite is being processed for launch on a Soviet vehicle. As I indicated during my confirmation hearings, I do not expect that current policy will change.

21 Your Office played a critical role in assuring that the commercial industry be accorded equal priority in obtaining access to AP supplies.

-- The industry has been assured of such access through the remainder of this year, isn't that correct?

--Do you envision problems for 1990 and beyond? How will the industry's concerns and AP needs be accommodated?

Yes. When the Federal Emergency Management Agency (FEMA) designated the commercial space launch sector to be a directly related national defense program under the Defense Production Act of 1950, the authorization for the commercial space launch program to receive allocations support extends through December 31, 1989.

At this time we do not envision problems for 1990 and beyond. A replacement for the Pacific Engineering and Production Company (PEPCON) facility is scheduled to start production of ammonium perchlorate in June of this year. OCST is in the process of polling commercial companies to determine what qualification procedures, costs and strategies could be employed to make use of this second facility.

Question No. 22. Are you involved in the NSC assessment of single sources and policy options for addressing them?

Yes. Our office along with NASA and DOD have participated in the assessment. The NSC group was established after the explosion destroyed one of the two ammonium perchlorate plants and AVTEX, the sole producer of aviation-grade rayon closed. Its purpose was to examine single sources for important components and materials. Since then, a replacement facility for the production of ammonium perchlorate has been under construction and is scheduled to start production in June. Also, AVTEX resumed its operation.

This assessment has been more complex and costly than originally anticipated. Most of the research on single sources is being done by NASA and the Air Force with some input from commercial companies.

Question No. 23. The Air Force has recently issued new requirements and procedures for access to the Cape, permitting only escorted access to non-classified areas. We understand the procedures are very onerous on foreign satellite owners who require access to the Cape for processing, integration and planning.

--What is the current status of this situation?
--Have these problems been adequately addressed by the Air Force, and other?
--What can DOT do about it?

There very clearly has been a problem with foreign access in the eyes of the satellite community. Ariane has been using the complexity of gaining access to U.S. ranges as a marketing tool in the foreign satellite markets.

The OCST has been working to resolve this problem. Initially, the OCST monitored foreign access attempts to access the magnitude of the problem. Once the seriousness and the nature of the problem were clear, OCST and the Air Force proceeded to consider mechanisms which might alleviate the payload community's concerns.

The problems of the community are two-fold. One is the method to gain access to the range, i.e., the requirement for foreign customers of U.S. launch companies to apply to their respective embassies in order to be able to work on their satellite at the launch facility. The other problem is the amount of time it takes for the Air Force to give approval for them to use the facility. The OCST is working with the launch industry to resolve the customers's concerns with regard to the embassies.

In the future, the customers will submit their names only to the launch companies. The Air Force is streamlining its operation and in the future a customer should be able to get on the range within two to three days of submitting his name to a launch company.

The OCST does not know at this time whether these actions are sufficient to resolve the foreign payload community's concerns. This office shall continue to monitor the situation and take appropriate action as necessary.